MINING engineering

DECEMBER 1955

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MINING BRANCH AIME

MINING engineering

VOL. 7 NO. 12 DECEMBER 1955

COVER

SEASONS GREETINGS from the Staff of MINING ENGINEERING

Cover by Herb McClure

FEATURES

ARTICLES

TRANSACTIONS

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, M.S., 29, married, one child. Five years varied experience in mine and milling operations. Desires production or engineering opportunity. M-246.

Geologist, 26; 2 years graduate geology. Experienced in diamond drilling operations, field mapping, and research; some experience in geophysical work. Desires position in geology, mining, or in administrative work. M-247.

Junior Mining Engineer, 28, married, 3 years college. Five years experience hard rock quarry. Desires position involving quarry or mine development engineering in West or Midwest. M-248.

Mining Engineer with broad experience in uranium, exploration, and development. Twenty years mineral exploration, development, and operation. Employed. M-249.

POSITIONS OPEN

Mining Engineer with shaft layout and field engineering experience covering shaft sinking. Salary, $6500 to $7800 a year. Location, New Jersey. W2454.

Assistant Mine Superintendent, 30 to 45, graduate mining engineer, experienced in underground mining. U. S. or Canadian citizen. Salary open. Housing available, also grade school. Location, Mediterranean area. F2424.

Geologist to supervise field work in Oregon. Must be well experienced in mining bauxite. Salary open. W2354S.

Geophysicist with exploration experience, including resistivity procedures and water well logging. Salary, $1000 a month minimum. Duration, 8 to 10 months. Location, French Equatorial Africa. F2397.

Manager, mining engineering graduate, experienced in mining of fluorspar. Any experience in mill construction very desirable. Must speak Spanish. Salary, $9000 to $12,000 a year. Location, Mexico. F2353.

Engineering Geologist to study and develop present and future raw material sources for a cement company. Location, Pennsylvania. W2470.

Mineralogist or Geologist with 1 to 3 years experience in mineralogy techniques, preferably with some training and experience in the study of polished sections. Location, Massachusetts. W2310.

Assistant Mine Superintendent and Assistant Mill Superintendent for large base metal mine in South West Africa. Should be technical graduate with at least 5 years base metal flotation experience. Three-year contract, transportation for self and family and salary while traveling. Furnished house available for married man. Climate and living conditions excellent. F2163.

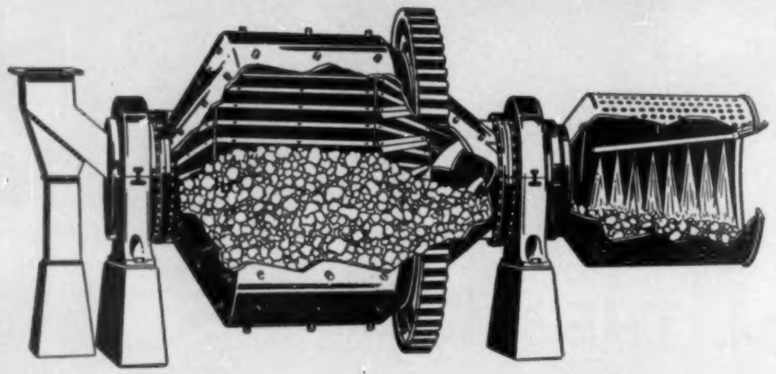
Project Engineer, 25 to 35, graduate mining or metallurgical engineer, to assist in design and development for mineral dressing, heavy chemical, cement, and rock products industries. Must have had engineering and field experience and be willing to work on drafting boards, travel, and do field service. Location, Pennsylvania. W2027(a).

(Continued on page 1076)

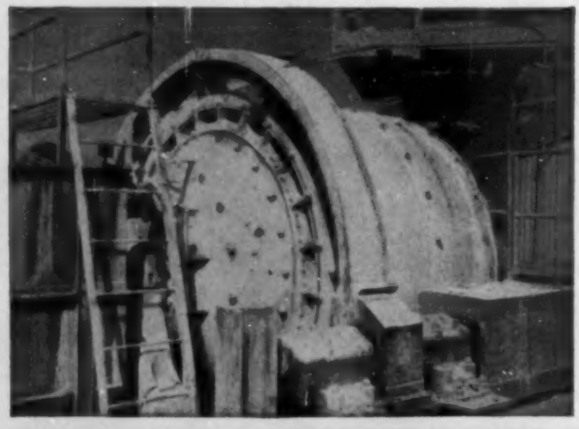
Technical Editors Wanted

Two positions are open at AIME headquarters for young engineers to do editorial work on MINING ENGINEERING and JOURNAL OF METALS. Men are desired with educational background and experience from the fields of extractive metallurgy, physical metallurgy, beneficiation, mining or economic geology. The primary qualification, other than a degree in one of the above fields and a minimum of 2 years experience in the mineral industries, is an interest in, or an aptitude for, editing and writing. The editorial work involves procuring articles of a news or technical nature; editing or rewriting them to meet magazine specifications; and supervising these articles and other sections of the magazine through all phases of magazine production. Applicants should apply to: Editorial Director, AIME, 29 W. 39th St., New York 18, N. Y., sending experience records, references, photograph, and any special qualifications for the job. Date of availability and salary requirements should be stated.

HARDINGE SCRUBBERS FOR PIT-RUN MATERIALS



Large diameter, short length trunnions permit chute feeding of unsized ore and rock at rates up to 600 tons per hour.
The mass loading and ball-mill action in the scrubber quickly and completely slurries the clay and dirt, permitting ready separation on washing screens or trommels.



View of a 10' x 66" Hardinge Scrubber cleaning crushed dolomite in a California plant.

Bulletin 37-A-2

HARDINGE
COMPANY, INCORPORATED

YORK, PENNSYLVANIA • 240 Arch St. • Main Office and Works

New York • Toronto • Chicago • Hibbing • Houston • Salt Lake City • San Francisco

— POSITIONS OPEN —

(Continued from page 1074)

Mining Engineer and Ore Dressing Engineer, young, for exploration and open pit iron ore mining engineering and ore concentration (washing, calcining, sintering, magnetic separation). Salary open. Location, South. W2394.

Graduate engineer thoroughly experienced open-cut mining preferably with Latin-American operating background needed for preparation estimates, later operation, location South America. Salary open. Send full professional record, salary desired, references. . . . .
Box 23-M AIME
29 West 39th St. New York 18

A young, progressive company, amply financed, headed by geologist, is seeking a senior geologist for evaluation of new prospects in the Western States. Man should be a senior field geologist with minimum of ten years experience in mapping and economic evaluation. Salary open.
Box 21-M AIME
29 West 39th St. New York 18, N. Y.

POSITION VACANT

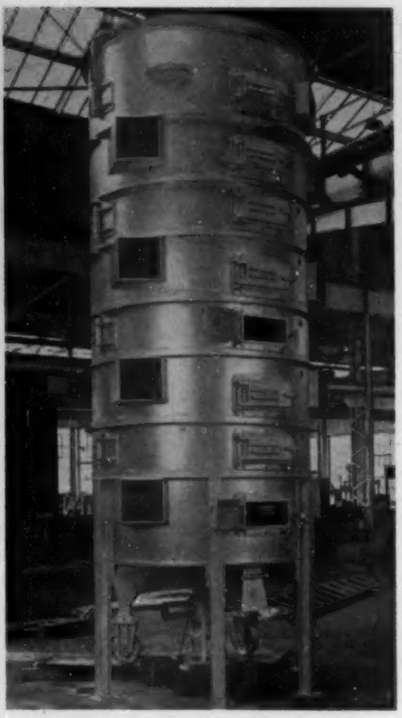
Wanted: Graduate engineer to fill vacancy in Engineering Department of large coal mining operation. Must be qualified for underground and surface surveying, mapping, and general drafting work and must be capable of designing simple structures. Man with experience preferred.

Apply: **INLAND STEEL COMPANY**
Wheelwright, Kentucky

Mining operation of 10,000 tons daily for integrated steel plant, northeast Texas, offers excellent opportunity for a Junior Mining Engineer and a Junior Ore Dressing Engineer. Both to undergo training program in exploration, open-pit iron ore mining engineering, and ore concentration (washing, calcining, sintering, magnetic separation). Recent graduates, up to 35, good health, salary commensurate with qualifications.
Box 20-L AIME
29 W. 39 St., New York 18, N. Y.

SALES ENGINEERS
Explosives manufacturer with nation-wide distribution has attractive openings for men with technical background or practical experience as sales engineers; age, under 30 preferred. Starting salary commensurate with experience. Considerable traveling is required. Liberal benefits. Every incentive for advancement.
This is an excellent opportunity for the application of your knowledge of mining, quarrying, construction, and related industries.
Send complete resume. Photograph optional. All correspondence will be held in strict confidence, and references will not be contacted without permission of applicant.
Box 22-M AIME
29 West 39th St. New York 18, N. Y.

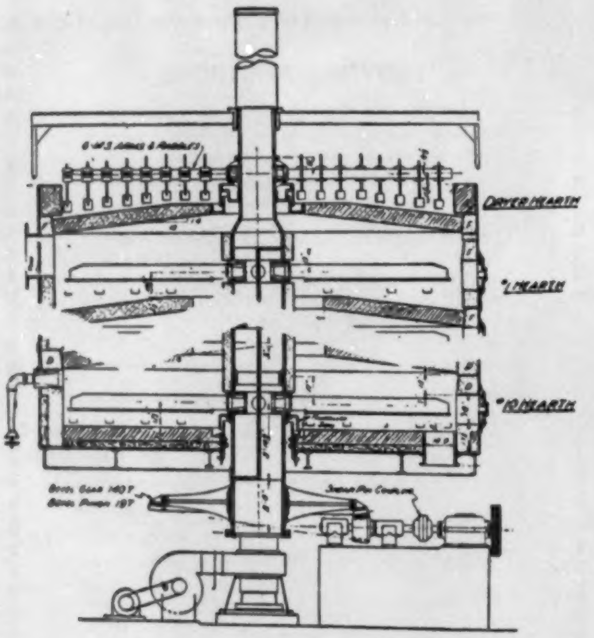
SKINNER
Multiple Hearth Roasters and Dryers



Proved in the Field for 37 Years... ...on many applications

Skinner Roasters, manufactured by Colorado Iron Works, have been used for efficient roasting and drying of ores, clays, limestone, lime-sludge; decomposing oil sludge in the process of recovering sulphuric acid. These applications include sulphide roasting; oxidizing, reducing and chloridizing roasts.

Skinner Roasters have been used from the beginning in the Uranium-Vanadium industry. In the case of asphaltic ores the roasters burn off the undesirable carbon. On non-asphaltic ores roasting facilitates extraction and has become standard practice for removal of the vanadium content through salt-roasting.



MECHANICAL FEATURES

Skinner Roasters consist of a series of superimposed hearths over which the material is rabbled by rotating arms and easily replaceable teeth. The rabble arms are fastened to the central shaft by means of the distinctive Skinner bayonet lock. The shaft is constructed to allow for ample cooling of both shaft and arms from a blower or by natural draft. Among the distinctive advantages of CIW Skinner Roasters are: small diameter rugged center shaft increases net hearth area and volume; simple vertical adjustment of central shaft; quick replacement of rabble arms and teeth without cooling; up or down-draft and multiple hearth gas off-takes permit wide range of control; negligible dust losses. Coal, oil or gas fired. Sizes 2 to 12 hearths; 4'-0" to 23'-6" inside diameter.

COLORADO IRON WORKS CO.

1624 17th Street • Denver 2, Colorado

AKINS CLASSIFIERS • SKINNER ROASTERS • LOWDEN DRYERS

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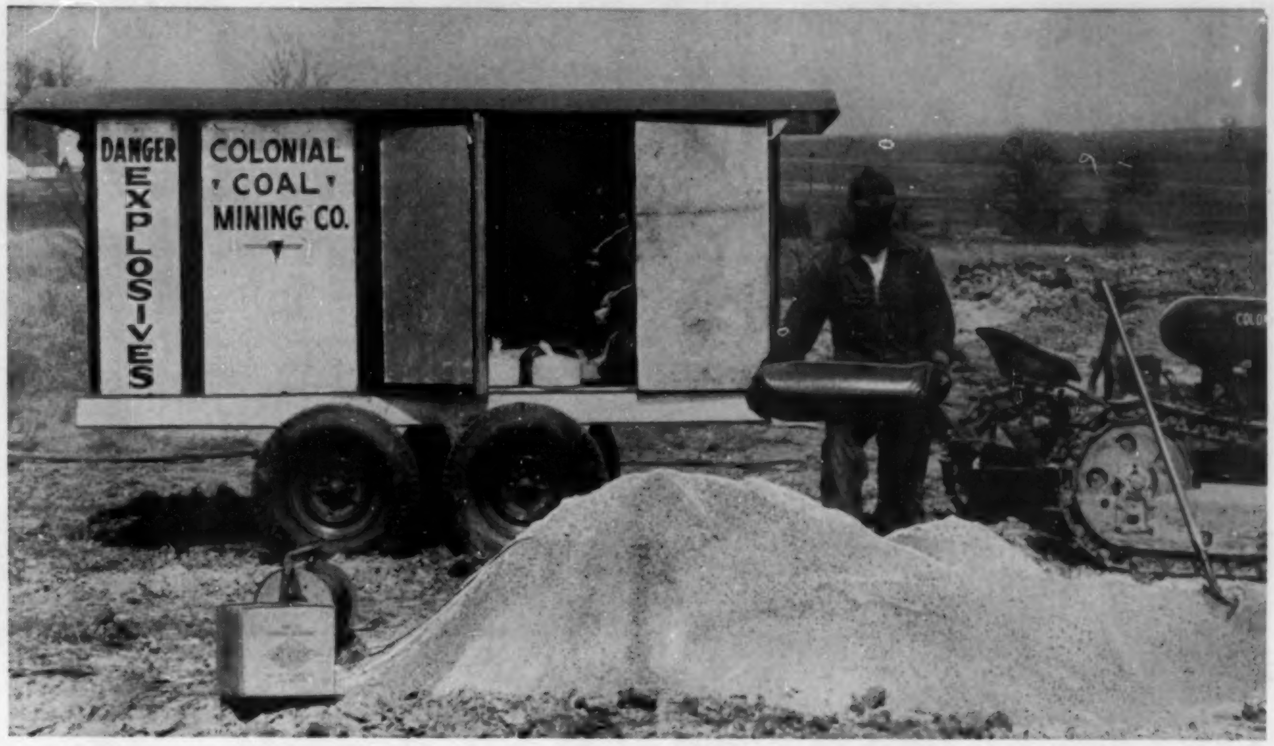
A SUBSIDIARY OF THE MINE & SMELTER SUPPLY CO.



How New Akremite Method Helps Us Cut Explosive Costs 40% to 60%

... main ingredient we use in new "make-it-yourself" explosive is Spencer Commercial Grade Ammonium Nitrate

By JAMES E. MINER, *President, Colonial Coal Mining Company*

THE "Do it yourself" fad is not restricted to the basement workshop as far as the Colonial Mining Co. is concerned. Strip miners of coal now are making their own explosive for overburden shooting.

Hugh B. Lee, president, and Robert Akre, superintendent of drilling and shooting, Maumee Collieries Co., Terre Haute, Ind., have developed a new type explosive for strip and open pit mining. Called the Akremite Blasting Process, Colonial Coal Mining Co. is now using the method under license from Maumee.

Drilling and shooting conditions will vary with each mine so that no rule of thumb can be used to show shooting costs. However, Akremite is saving us 40% to 60% compared with the cheapest commercial explosive and is giving at least equivalent results when shot on a pound for pound basis.

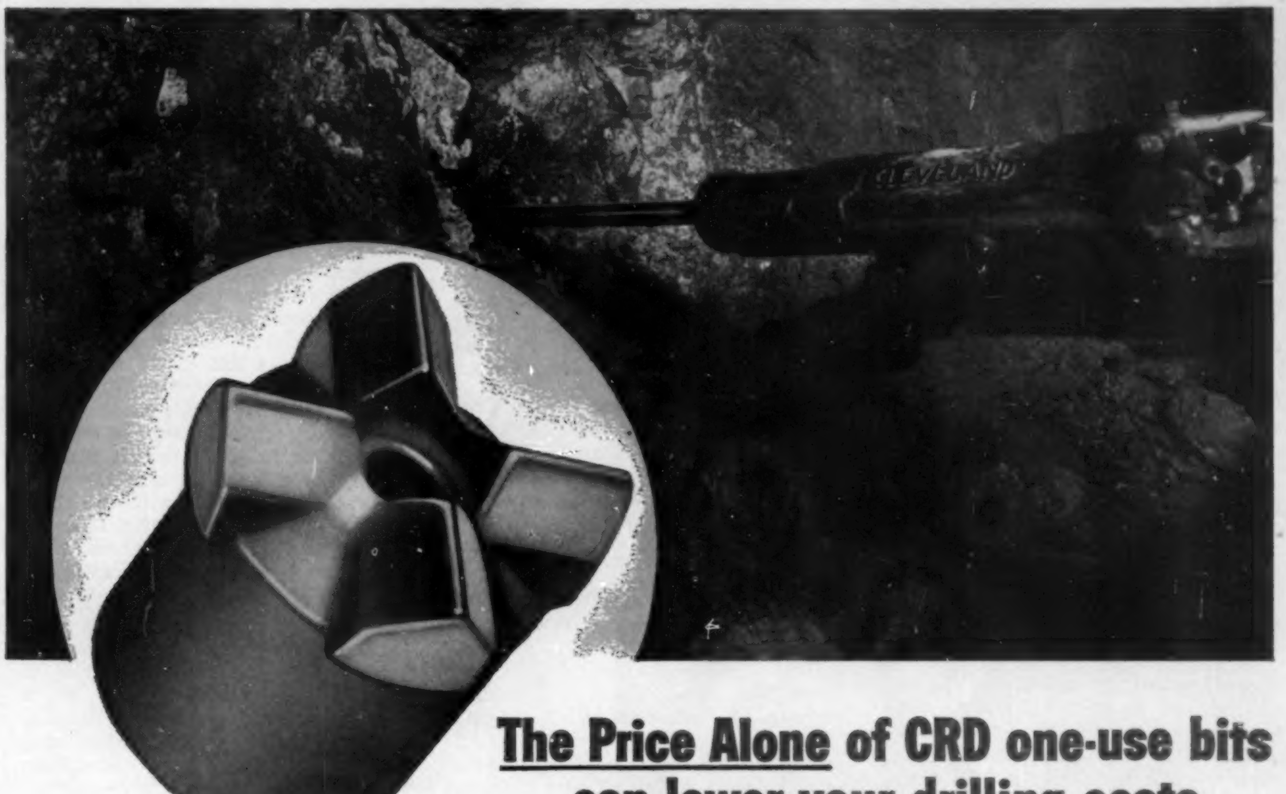
For a specific example of the savings, take our experience at Colonial Mine. We purchased a Bucyrus-Erie 50-R drill and began using Akremite about a year ago. For an 11-month period after using this combination we enjoyed an 18-cent per ton reduction in drilling and shooting costs over a like period before its use, while our stripping ratio was reduced by one yard, from 7½ to 1 to 6½ to 1. Depreciation of the drill is included in the calculations of cost.

The main ingredient in the Akremite Method is a commercial grade ammonium nitrate. We use Spencer Commercial Grade Ammonium Nitrate. A great deal of practical research has been done by the Spencer Chemical Company in cooperation with Maumee Collieries to produce this raw material with the proper moisture content, density, screen analysis, caking quality and ability to take the correct carbonaceous coating.

(NOTE: Spencer Chemical Company will be happy to provide you with further information about the Akremite Method as discussed by Mr. Miner.)

SPENCER CHEMICAL COMPANY

610 Dwight Building • Kansas City 5, Missouri • Baltimore 6600



The Price Alone of CRD one-use bits can lower your drilling costs

. . . and they are made and backed by CLEVELAND Rock Drill

How do Cleveland CRD one-use bits save you money? It's just plain economics. You see, the price of CRD bits on an average, is less than one-half that of a multi-use bit. In fact, the price of a CRD bit comes close to matching the cost of reconditioning a multi-use bit.

So the price alone of CRD one-use bits can help you cut your drilling costs. But there are other reasons to use CRD bits, too.

Faster Drilling Speed — Special offset gauge feature, which permits the use of thinner wings and a steeper reaming angle, greatly reduces binding and provides ample clearance for cuttings. Result is a free, fast-cutting, chiseling action that gives you greater drilling speed.

Less Drill-Steel Breakage — The method of attachment used with the CRD bit eliminates threads on the drill rod. Since a drill rod is only as strong as the root diameters of its threads, the tapered threadless CRD design provides longer drill-steel life — reduces drill-steel handling and reconditioning costs.

Lower Rock Drill Repair Costs — Because the CRD bit design reduces binding in the hole, there is less strain on the rotation parts of your rock drills. Rifle bars, rifle nuts, and chucks last longer. You get more drilling done at lower cost.

Since no special equipment is needed for reconditioning bits or threading rods, you owe it to yourself to try a can of CRD bits. They're ideal for roof bolting and for use in your stopes as well as in your headings. A short trial will give you first-hand information on the ability of these bits to cut drilling costs in your property, as they have in so many others.

Bulletin RD-29 gives detailed information. A copy is yours for the asking — just write for it.

Pneumatic knock-off machine makes it still easier and quicker to use CRD bits. Hand knock-off tools also available.

S P E C I F I C A T I O N S

Mines everywhere cut drilling costs with CRD DETACHABLE DRILL BITS
4-Wing Type — Center Hole — Side Hole

Series "A" Bits For series "A" drill steel connection on any steel. Best suited to 7/8" steel.	1 1/4	Aluminum	Series "B" Bits For series "B" drill steel connection on any steel. Best suited to 1", 1 1/8", and 1 1/4" steel.	1 7/16	Orange
	1 5/16	Pink		1 1/2	Green
	1 3/8	Deep Green		1 9/16	Yellow
	1 7/16	Brown		1 5/8	White
	1 1/2	Grey		1 11/16	Black
	1 9/16	Maroon		1 3/4	Red
	1 5/8	Deep Blue		1 13/16	Blue
				1 7/8	Tan
				1 15/16	Plain
				2	Pink
				2 1/8	Maroon
				2 1/4	Aluminum

Cans are labeled showing size of steel socket, gauge of bit, and color.

CLEVELAND ROCK DRILL DIVISION
Westinghouse Air Brake Co.

12500 BEREA ROAD
CLEVELAND 11, OHIO

RD-6D

The Mining and Dressing of Low-Grade Ores in Europe, *Organisation for European Economic Cooperation,* 2002 P St. N.W., Washington, D. C., $2.75, 340 pp.—In 1953, 24 leading European experts visited ore-dressing plants and laboratories in five European countries. Their report is divided into two parts. Part I discusses the economics of the low grade ore problem and technical aspects including research facilities and recruitment and training of engineers. Part II deals in detail with the various processes of comminution and separation used in Europe, notably the flotation of oxide ores. The appendices contain excellent flowsheets and short technical descriptions of some 28 plants and research establishments visited by the Mission. U. S. readers will be particularly interested in fundamental research carried out by the Royal School of Mines in England and the Swedish Institute of Technology.

Principles of Flotation, by K. L. Sutherland and I. W. Wark, *Australasian Institute of Mining and Metallurgy,* 399 Little Collins St., Melbourne, Australia, £4.3.6 (approximately $9.35) for nonmembers; £3.3.6 (approximately $7.11) for bonafide students; prices include postage, 489 pp., 1955.—The original edition of this book, published in 1938, was written by I. W. Wark. The demand for it persisted long after the original edition was exhausted. This revised and enlarged version is the joint work of Mr. Wark, chief, Div. of Industrial Chemistry of the Commonwealth Scientific & Industrial Research Organization, and Mr. Sutherland, assistant chief of that Division. An excellent reference and text, it will be of value to those in mineral dressing, surface chemistry, and industrial chemistry fields.

Some Effects of Precipitation on Ground Water in Wisconsin, by William J. Drescher, *Wisconsin Geological Survey,* University of Wisconsin, Madison, Wis., IC No. 1, 20¢, 17 pp., 1955. Illustrated.

Forages et Sondages, Leur emploi dans les Travaux Publics, by H. Cambefort, *Editions Eyrolles,* Paris, available in the U. S. from Stechert-Hafner, 31 E. 10th St., New York 3, N. Y., approximately $10.00, 396 pp., 1955.—More than half of this book in French on drilling and boring operations is concerned with the equipment and methods for rock drilling: types of drills, headgear, casings, theory and practical procedures, drilling mud, etc., with some treatment of the geometrical characteristics of boreholes. Part II covers the taking of core samples and borehole logging. Part III discusses the use and value of drilling procedures in civil engineering operations, particularly with respect to foundations.

A Magnetometer Survey of the Keene Dome, McKenzie County, North Dakota, by Albert G. Opp, *North Dakota Geological Survey,* Grand Forks, N. D., RI 19, 50¢, map sheet with text, 1955.—A survey conducted in 1954 using a Ruska, type V, vertical intensity magnetometer. Corrected station values were plotted on a base map and isogamma contours drawn. Relationship between magnetic anomalies and oil fields "is not always too clear since the oil fields are still in the development stage."

Subsurface Correlations of the Cretaceous Greenhorn-Lakota Interval in North Dakota, by Dan E. Hansen, *North Dakota Geological Survey* Grand Forks, N. D., Bulletin 29, $1.50, 46 pp., 2 pl., 10 fig., 3 tables, 1955.—Rock samples and mechanical logs from petroleum exploration wells were studied to obtain data.

Geology of Southern California, compiled and edited by Richard H. Jahns, *California Div. of Mines,* Ferry Bldg., San Francisco 11, Calif., Bulletin 170, $12.00 postpaid, 878 pp., 1955.—This gigantic symposium is the product of 103 technical experts in academic, industrial, and governmental positions. It consists of 441 text figures, an index map, 60 route maps to selected geologic trips, and 34 map sheets with texts and illustrations. Weighing 10 lb, the book comes in a sturdy cardboard box. Inside, and separately bound, are five road logs, ten chapters, and a preface. The 34 map sheets are encased in an expanding envelope. Other maps are included in back cover pockets. There are numerous and excellent photographs throughout the text.

X-Ray Diffraction by Polycrystalline Materials, edited by H. S. Peiser, H. P. Rooksby, and A. J. C. Wilson, *Institute of Physics,* 47, Belgrave Sq., London, S.W. 1, England, 63s. (approximately $8.82), 725 pp., 1955.—The first two parts of this advanced treatise are devoted to the discussion of experimental techniques and equipment and to the interpretation of data. The third part deals with the practical uses of the techniques in a number of fields including mineralogical research, refractories and ceramics, metallurgical research, and atomic energy research. Individual chapters were written by some 30 members of the X-ray Analysis Group of the Institute of Physics.

International Conference on the Peaceful Uses of Atomic Energy: Proceedings. Geneva 1955, *Walter J. Johnson Inc.,* 125 E. 23rd St., New York 10, N. Y., 16 volumes (approximately 500 pp. per vol.), prepublication price, valid until Dec. 31, 1955, $110.00.—These volumes will consist of all papers presented orally or in written form and will be the only complete record of this conference.

BOOKS

An Introduction to Mineral Dressing, by E. J. Pryor, *Mining Publications Ltd.,* London, approximately $9.80, 649 pp., 1955.—This well organized book meets a need in its field. The author is reader in mineral dressing, University of London. His book is based upon the elementary course in mineral dressing given to students of mining, mineral dressing, and metallurgy at the Royal School of Mines. It sets forth the basic principles that underlie sound milling practice and shows their relation to standard commercial operations. Mr. Pryor has visited a wide range of laboratories and plants in the U. S., Canada, Europe, and Africa to study the principles of mineral dressing and their commercial application.

Handbook of Engineering Materials, edited by Donald F. Miner and John B. Seastone, *John Wiley & Sons Inc.,* $17.50, 1382 pp., 1955.—Designed to meet the need of engineers for a convenient single source for data on the usual materials of manufacturing and construction, this handbook gives essential information concisely and suggests sources of more complete information. Arrangement is by classes of related or similar materials under three broad groups—metals, nonmetals, and construction materials. In general information given includes grades, properties, applications, sources of supply and—where pertinent—design, fabricating, and other data. The first section provides general information on specifications, standards, constants, etc., and there is a detailed subject index.

Chemical Processing and Equipment, U. S. Atomic Energy Commission, *McGraw-Hill Book Co. Inc.,* $6.00, 302 pp., 1955.—One of a series of reports prepared for the International Conference on the Peaceful Uses of Atomic Energy, this volume includes a brief review of the facilities, equipment, and process initially provided at the Idaho Chemical Processing Plant for uranium recovery from uranium-aluminum alloy fuels such as those used in the materials-testing reactor and the bulk-shielding reactor. More than five-sixths of the book is devoted to the application, description, and operation of laboratory equipment for the handling of highly radioactive materials and to discussion of the layout of an existing laboratory.

Brand of the Tartan, by Virginia Huck, *Appleton-Century-Crofts Inc.,* $3.50, 250 pp., 1955.—The history of the 53-year old Minnesota Mining & Mfg. Co., producers of roofing granules and other products. Once a small mining concern that found its product worthless, this company is now one of the most prominent customers of the mining industry.

MEMBERS, ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten pct discount given whenever possible.

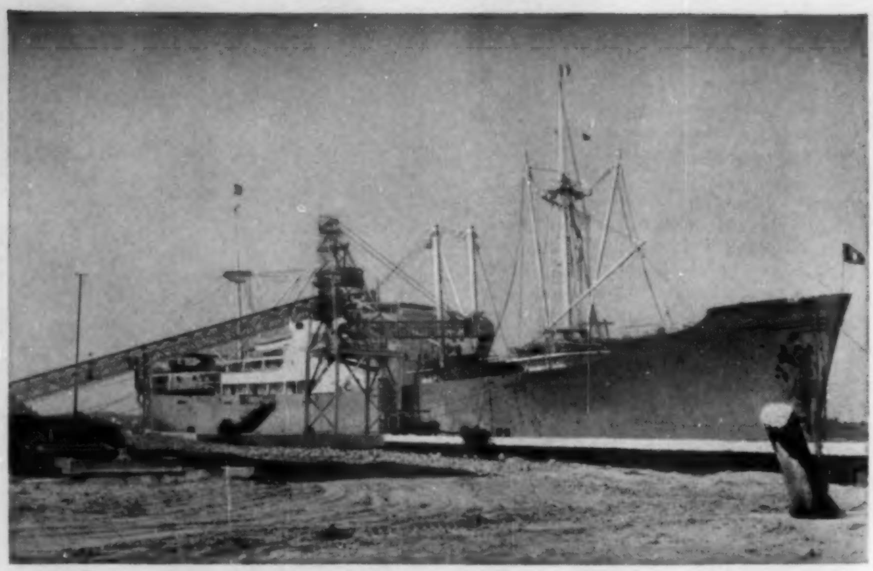
Prospecting for Atomic Minerals, by Alvin W. Knoerr and George P. Lutjen, *McGraw-Hill Book Co. Inc.*, $3.95, 211 pp., 1955.—Mr. Knoerr is chief editor and Mr. Lutjen is managing editor of *Engineering & Mining Journal.* Their information was gathered from successful uranium prospectors, AEC officials, mine owners and operators, U. S. and Canadian mining bureaus, and from numerous trips throughout the Colorado Plateau. Written in simple, nontechnical terms, their book covers modern equipment, basic survey instruments, radiation detectors, health precautions, and use of maps. It tells how to look for and identify atomic ores, how to obtain, protect, and prove a claim, how to determine the extent and value of an orebody, how and where to sell. State and Federal laws are included, as well as maps of available research. Well illustrated.

Atomic Research at Harwell, by K. E. B. Jay, *Philosophical Library,* $4.75, 144 pp., 1955.—This book from the United Kingdom Atomic Energy Authority is a continuation of *Harwell—the British Atomic Energy Research Establishment, 1946-1951.* It describes the work done at Harwell from 1951 to 1954. Changes in regulations have made it possible to discuss in more detail some of the subjects only mentioned in general terms in the earlier book. Part I concerns major programs and is written primarily for nontechnical readers. Part II dealing in more detail with selected researches is written for scientific readers who have not specialized in various fields discussed.

Problems and Control of Air-Pollution, edited by Frederick S. Mallette, *Reinhold Publishing Corp.*, $7.50, 272 pp., 1955.—Proceedings of the First International Congress on Air-Pollution held March 1955 under the sponsorship of the American Society of Mechanical Engineers. Chapters on treatment and recovery of sulphur dioxide should interest management and technical personnel concerned with the control of sulphur gases from the burning of fuels or from processing operations.

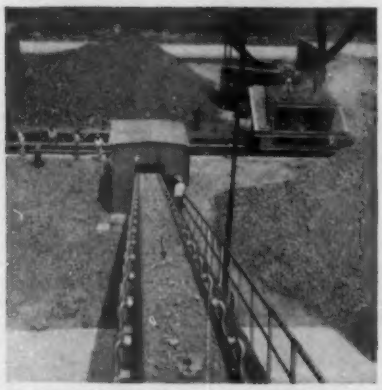
Silicic Science, by Ernst A. Hauser, *D. Van Nostrand Co. Inc.*, $5.00, 188 pp., 1955.—This monograph covers the composition and structure of siliceous compounds, ion-exchange reactions of silicate, ultra and electron-microscopy of silicates and clays, the reaction of bentonite with organic compounds, and related subjects. Soil stabilization and silicones are treated in separate chapters, and the last chapter briefly reviews applications of silicic chemistry in ceramics, drilling fluids, and other fields.

From the Jungles of VERACRUZ



They're Loading Sulphur for the Free World!

with an S-A CONVEYING SYSTEM...



Sulphur is weighed "on-the-run" as it rides slope conveyor to loading tower.

Ship loading boom conveyor in raised position to clear ship superstructure.

Deep in the jungle of the state of Veracruz, Mexico, liquid sulphur flows from pipes probing 600 to 1000 feet into the ground. This is the first sulphur plant using the Frasch process outside the United States.

First put into production in March 1954, the Mexican Gulf Sulphur Company's operation is the result of teamwork of United States and Mexican technicians. Engineered for a production of 200,000 tons per year, the plant has a planned potential of 500,000 tons annually.

After a barge trip to storage and shipping facilities, the sulphur is solidified in vats. Then, blasted loose, it is delivered to a Stephens-Adamson Conveyor System. A traveling hopper with crusher "working over" to belt conveyors, reduces lumps to 6-inch size. Both belts feed to a slope conveyor, running to a loading tower at dockside. Belts have a normal capacity of 400 TPH each.

From the unloading tower, sulphur moves out on a boom conveyor for ship loading, or is directed to a chute for loading railroad cars.

Another good example of S-A engineering to meet a specific need for economical handling. What is *your* problem? We'd like to help you solve it. Just write for full details.

SINCE 1901 · S-A · STEPHENS-ADAMSON MFG. CO.

STEPHENS-ADAMSON MFG. CO.

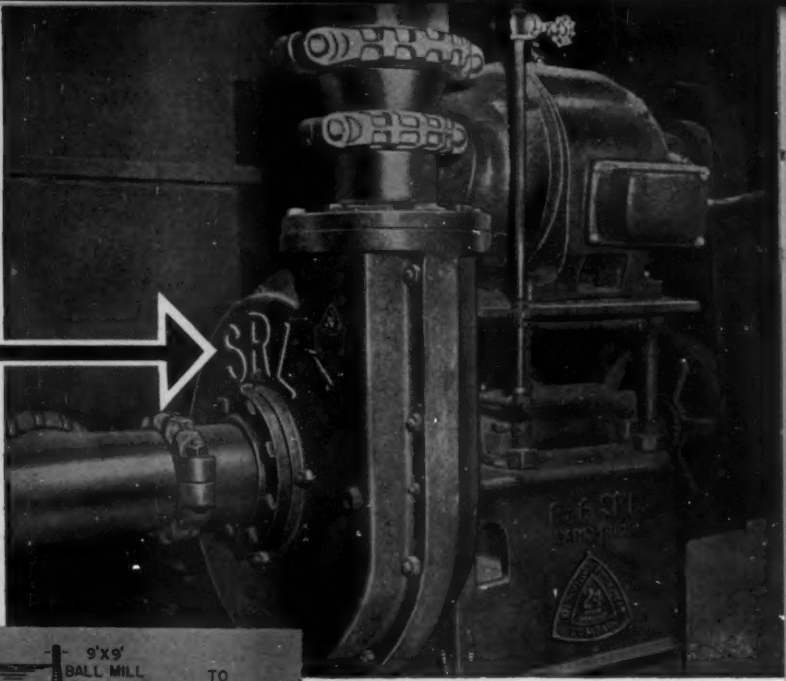
37 Ridgeway Avenue, Aurora, Illinois • Los Angeles, California • Belleville, Ontario

Engineering Division
Specialists in the design and manufacture of all types of bulk materials conveying systems

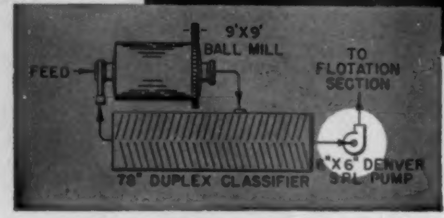
Standard Products Division
A complete line of conveyor accessories, centrifugal loaders—car pullers—bin lever controls

Sealmaster Division
A complete line of industrial ball bearing units available in both standard and special housings

DENVER SRL PUMPS AT Climax



Here's why Climax Molybdenum Company has 44 Denver SRL Sand Pumps in it's modern, efficient mill



A 6"x6" Denver SRL Sand Pump operating at 690 r.p.m., handling 2200 tons per 24 hours of —28 mesh classifier overflow material at 45% solids. Life of pump runner and casing liner was 593,000 tons.

BACKGROUND

Originally, a 2"x2" Denver SRL (Rubber Lined) Sand Pump was installed on a trial basis at Climax to handle coarse, abrasive —28 mesh deslimed pyrite flotation concentrates. Later, Climax purchased one 6"x6" Denver SRL Pump to handle the problem described with the photo above.

RESULT

Operation of these original Denver SRL pumps was so successful that, as a direct result, 42 additional Denver SRL Sand Pumps have been installed in this outstanding mill. These new pumps vary in size from the 2"x2" SRL (Open Runner) to the 8"x6" SRL-C (Closed Runner).

REASON

The Climax operators have found the efficient, trouble-free operation of Denver SRL Pumps entirely satisfactory. Life of wearing parts is long and shut-down time minimized. Horsepower requirements have been low and high efficiencies have resulted. Obviously, the Denver SRL is a big success at Climax.

HOW DENVER SRL PUMPS CAN REDUCE YOUR PUMPING COSTS

Send full data to us today regarding your particular pumping problem. Experienced DECO engineers will evaluate your problem and will return correct and workable recommendations immediately. This will obligate you in no way.

We carry replacement parts for all sizes of Denver SRL Sand Pumps in our Denver stocks. This enables us to give you prompt service whenever you may need it.

WRITE FOR FREE BULLETIN

DECO FLOTATION ENGINEERS

DENVER EQUIPMENT COMPANY 24 HOUR SERVICE

"The firm that makes its friends happier, healthier and wealthier"

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DENVER EQUIPMENT CO., 1400 Seventeenth St., Denver 17, Colorado

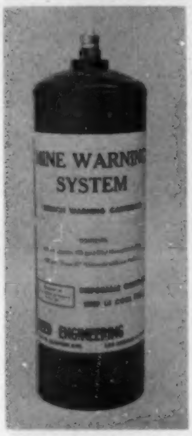
Manufacturers News

News
Equipment
Catalogs

• FILL OUT THE CARD FOR MORE INFORMATION •

Mine Warning System

Reed Engineering's stench warning system is designed to be self-injecting into 100 psi air-lines. The steel pressure cylinder contains ethyl mercaptan plus a surplus of an inert gas propellent and flame quencher. Inert propellent renders mixture nonexplosive, as shown by recent USBM tests. A single flexible connection to the airline renders unit ready for use. **Circle No. 1.**



Underground Diesel

A 2-ton diesel powered locomotive for 18 or 24-in. gage track has been added to the *Mancha Storage Battery Locomotive Div.* line. A 30-hp Hercules engine provides for up to 1000-lb drawbar pull. The power train utilizes a hydraulic torque converter. **Circle No. 2**

Face Protection

Made by *Mine Safety Appliances Co.*, the MSA Skullgard-Faceshield can be quickly attached and removed from any MSA protective hat

without marring the hat. Aluminum pivot arm permits the clear acetate visor to be swiveled up or down in any desired position. Visors are easily detached for replacement. **Circle No. 3.**

Self-regulating Pump

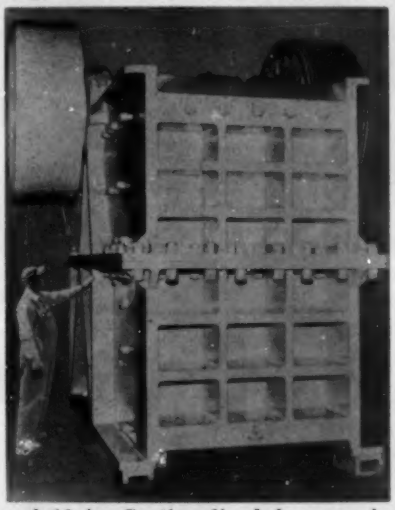
Ingersoll-Rand has an industrial liquids pump with a diverging-type impeller that enables pump to handle liquids containing high concentrations of solids, air, and gases. The greater area at discharge rather than inlet prevents vapor binding, avoids clogging, and makes the pump self-venting. **Circle No. 4.**

Miniature Seismometer

Houston Technical Laboratories makes a velocity-type seismometer for multiple array use in land exploration. The S-39 dualDAMP is so named because it employs both electromagnetic and fluid (Dow Corning type 200) damping. It is $1\frac{7}{8}$ in. high, $1\frac{1}{2}$ in. diam, and weighs only 11 oz. Price: $10.00 in the U. S., Mexico, and Canada; $11.00 in other countries. **Circle No. 5.**

Jaw Crusher

Type J 36x48-in. jaw crusher made by *Denver Eqpt. Co* has estimated capacity of 275 to 750 tph, depending on rock and discharge setting, which is variable between 4



and 10 in. Sectionalized for ease in handling component parts during installation, frame is extra heavy electric welded 3-in. steel plate. **Circle No. 6.**

Dual-Purpose Wire

Simplify your warehouse problems: that's the message of Densheath 900 dual-purpose building or appliance wire from *Anaconda Wire & Cable Co.* Product is available in sizes from No. 14 AWG to 2000 m circ mills when used as TW in Code applications; or in sizes from No. 14 to 4/0 AWG when used as an appliance wire. **Circle No. 7.**

Grinding Plates

To answer a need for chemical, rock, and mineral pulverizing, *Bico Inc.* has developed ceramic plates that have produced 100-mesh samples practically free from contamination. Made of alumina ceramic, a material hard enough to stand continual service, these plates are claimed to have longer life and vibration-free operation because of a patented pattern of plate surface. **Circle No. 8.**

Rock Bit

Carbide-insert *Brunner & Lay* Rok-Bit is designed for use on J-7.50 threaded drill rods. Available in 4 and $4\frac{1}{2}$-in. gage sizes, it fits directly on the steel without adapter. The

five air holes—three on face, two on sides—are claimed to mean better chip removal, since bit is not working in its own cuttings. **Circle No. 9.**

Continuous Weighing

Electrical weighing system uses an SR-4 load cell supplied by *Baldwin-Lima-Hamilton Corp.* Metering provides for transmission of weight measurements to recording instrument in mine office. Besides simpli-

fying measurements of coal shipments and mine production, this method is said to give the company's customers greater reliance on bills of lading than those determined by water displacement of barges. **Circle No. 10.**

Heavier Tractor

International Harvester's 300 utility model rubber-tired 42-hp wheel tractor weighs 3820 lb—1000 lb more than tractors of comparable size and class. Added weight is claimed to provide greater traction, stronger power train, and stronger axles. Torque amplifier gives 10 speeds forward from 1.5 to 16.7 mph, with speed and power changes up to 45 pct without operator shifting gears or touching throttle or clutch. **Circle No. 11.**

Blocking out uranium find with truck-mounted drilling rig. Gardner-Denver WH365 compressor feeds air to Gardner-Denver deep hole drills for fast, low-cost drilling.

Make your own road in with Gardner-Denver portable and hand held drills — then use them for development work.

Free Literature

(21) CLAMSHELL BUCKETS: *Blaw-Knox* bulletin 2373-R has carefully indexed information on efficient use of counterweights, bucket reeving, cable life, welding procedures, and other practical advice for clamshell bucket operators. Forty-page illustrated booklet also has a list of common abuses leading to early bucket failure and proper lubrication practices.

(22) LOADER: Catalog G-112 from *Goodman Mfg. Co.* states that the 965 loads up to 10 tpm in free coal and handles rock or slate. With a 26½-in. overall height, machine features 40 hp for loading, and 30 hp for tramming and hydraulic control system.

(23) SAMPLE SPLITTERS: Leaflet from *Carpco* shows sampling equipment developed for accurate sampling of fine materials that segregate easily, particularly low grade and radioactive ores.

(24) MATERIALS HANDLING: Latest issue of "Material Handling News," from the Industrial Truck Div., *Clark Eqpt. Co.*, contains studies of handling techniques in ten industries, illustrations of unusual uses of fork trucks, and descriptions of new equipment.

(25) BASIC REFRACTORIES: *E. J. Lavino & Co.*, which has been serving the copper industry since 1918, has a bulletin 6-22-77A revised to show prices effective Oct. 1, 1955. Among many Lavino firsts are: plastic chrome ore, all-chrome brick subhearth in a basic open hearth furnace, and plastic chrome ore lining in open hearth doors and runners.

(26) BOILER TUBE CORROSION: Tubular Products Div., *Babcock & Wilcox Co.*, has a bulletin, "Eleven Ways to Avoid Boiler Tube Corrosion." Many of the causes of corrosion in boiler tubes are explained in detail, along with suggested methods of eliminating these same causes.

(27) CENTRIFUGAL PUMPS: Form 7223-A from Cameron Pump Div., *Ingersoll-Rand* presents a complete line of cradle-mounted type general purpose centrifugal pumps. Capacities range from 5 to 2800 gpm; pressures from 10 to 525 ft total head.

(28) PITY THE WEARY WELDER: *Tweco Products* has a lightweight, flexible aluminum welding cable said to be easier and less tiring for

welders to handle. Tweco-Lite weighs one half as much as conventional copper welding cable and costs about 20 pct less.

(29) MINER'S LAMP: *Mine Safety Appliances Co.* has a 4-page brochure on the Edison R-4 electric cap lamp. The lamp, a product of Edison and MSA research, and the exclusive nickel-iron-alkali Edison battery that powers it are shown in photographs and detailed drawings.

(30) CRUSHING: *Pennsylvania Crusher Div.* has a booklet containing two articles by Benjamin B. Burbank, "Measuring the Crushing Resistance of Rocks and Ores" and "Measuring the Relative Abrasiveness of Rocks, Minerals, and Ores."

(31) LABORATORY APPLIANCES: Manufacturer-distributor of laboratory appliances and reagent chemicals, *Fisher Scientific Co.* has 112-page catalog listing all the instruments, apparatus, and accessories added since 1952 publication of the major Fisher catalog.

(32) TALC CONVEYING: *Fuller Co.* has a 4-page reprint of a technical article illustrating an expanded conveying system at a talc plant. Reprint explains how Fuller-Kinyon conveying system was successfully expanded to keep pace with increased production of finished talc when plant capacity was almost doubled.

(33) FINE COAL DRYING: "Fluo-Solids Systems for Fine Coal Drying" from *Dorr-Oliver Inc.* shows operation, advantages, theory, and background of this new fluidized coal drier. First system has been in successful operation for months with no oxidation in the finished product. Drying 70 to 90 tph, the 7-ft reactor operates at 150° to 155°F and handles coal as coarse as 1½ in. diam.

(34) CONTINUOUS MINER: Bulletin from *Joy Mfg. Co.* covers the 1CM-2B continuous miner with hydraulic rotary roof-bolting drills. Pivotally mounted on the crawler for maximum torque and penetration, drills can be quickly positioned and swing from 30° toward the miner to 24° from the machine.

(35) CONCRETE TESTER: *Soiltest Inc.* has a bulletin on the 200,000-lb capacity model CT-711 concrete tester. Providing laboratory accuracy in the field, this portable testing machine handles cubes up to 6 in., cylinders up to 7 in., and beams up to 40 in.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Mar. 15, 1956—if mailed in U. S. or Canada.

Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

1	2	3	4	5	6	7	8	9	10
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51	52	53	54	55	56	57	58	59	60
61	62	63	Students should write direct to manufacturer.						

Name____________________ Title__________

Company______________________________

Street______________________________

City and Zone__________________ State__________

(36) CABLE TOOL JOINTS: Available from *Spang & Co.* is a 4-page, illustrated folder on "The Care and Use of Cable Tool Joints."

(37) INSTRUMENTATION: Some of the subjects discussed in the 28-page bulletin from *Hagan Corp.* are automatic control and instrumentation components, water conditioning and steam testing equipment, chemical feeding devices, chemicals for metal protection. Bulletin also summarizes products of Hagan's three subsidiaries: Calgon Inc., Hall Laboratories Inc., and the Buromin Co.

(38) FIRE & ACCIDENT: *Loss Control Associates* has an index and directory covering information on accident prevention, fire control, health, and sanitation contained in nationally recognized codes and standards, and reliable references.

(39) TEMPERATURE CONTROL: *Leeds & Northrup Co.* has a 4-page data sheet on L&N's Speedomax H electropneumatic controllers. This current-adjusting type of system combines the advantages of pneumatic control with the flexibility and fast response of an electrical system.

(40) RUGGED FEEDERS: *Stephens-Adamson's* bulletin 255 covers S-A Amsco manganese steel feeders that "are made of the steel that work-hardens under impact." They are used "where the going gets too tough for ordinary feeders" and where large tonnages of heavy, abrasive, lump materials must be handled at lowest cost.

(41) LAB OR PILOT PLANT: Illustrated with photographs, drawings, and charts, a 76-page catalog from *Denver Eqpt. Co.* will help you to establish your own laboratory testing needs. Shown is complete equipment for assaying and batch or continuous test plants employing flotation, cyanidation, or gravity concentration.

(42) FANS: *Chicago Blower Corp.* has a bulletin on axial airfoil fans for ventilation under all kinds of conditions. Designed in eight general categories, fans are of heavy steel construction and available with direct or V-belt drive.

(43) PIT & QUARRY: In "Profit Producers in Pit and Quarry" satisfied owners of *Caterpillar* equipment explain how they have economically overcome adverse conditions. Illustrated are diesel en-

gines, track-type tractors, bulldozers, wheel-type tractors, scrapers, and wagons engineered to meet the demands of shock loads, constant exposure, clouds of abrasive dust, and continuous operation.

(44) MAGNETIC DRUMS: Bulletin MD 200 explains applications and features of *Homer* permanent magnetic drums. They automatically and economically remove tramp iron or ferrous material from gravity or conveyor transported products in the processing of chemicals, minerals, cement, slag, ore, sand, coal, etc.

(45) TEMPERATURE CONTROL: *Burling Instrument Co.* has a condensed catalog G-20 covering a complete line of differential expansion temperature controls. Included is an instrument selection chart.

(46) LASTING PUMP: Information is available from *Linatex Corp. of America* on what is claimed to be "the most lasting pump in the world." Design utilizes a living, natural rubber that is stabilized by a patented process. This gives it "greater resistance to abrasion than any known material."

(47) TRACTOR SHOVEL: Engineering, design, and production of the *Allis-Chalmers* HD-11G tractor shovel are pictorially presented in an 8-page catalog. HD-11G has 2¼-yd capacity, 105 net engine hp, a dumping height of 11 ft, 7 in., and weighs 32,000 lb.

(48) PILOT PLANT DRIER: *Hardinge Co.* has a leaflet on the Ruggles-Coles portable pilot plant drier. Designed especially for laboratory use, this single shell, direct-fired, rotary drier is applicable also for small capacity unit processes requiring a drying step, either intermittently or continuously.

(49) AIRBORNE COUNTER: Made by *Universal Atomics Corp.*, the 15-lb Airsco is one-man operated. An automatic system enables the pilot to devote all his attention to flying and yet be warned by a loud, clear signal in his earphones when he flies over a radioactive deposit.

(50) LUBRICANTS: Bulletin from the *Alpha Molykote Corp.* lists 17 types of Molykote. Diagrams illustrate the importance of this molybdenum disulphide compound in extreme bearing pressure, and high, low, and normal temperature lubrication applications.

(51) HOSE: *Flexaust* hoses and Portovent ducts are designed for moving air, gases or materials by pressure, suction or gravity and are made with neoprene impregnated and coated fabrics. Price leaflet shows vinyl wearstrip construction.

(52) MOBILE AC: "Now . . . AC Power Goes Anywhere a Vehicle Can Go" illustrates and provides technical and application data on *Star-Kimble's* mobile AC generators. Units supply up to 10 kw at standard voltages and frequencies, yet are small enough to be mounted under the hood of a car or truck.

(53) THE CUSTOMER TAKES OVER: Six letters in a bulletin from P&H Electric Shovel Div., *Harnischfeger Corp.*, are an enthusiastic endorsement of P&H equipment. Asbestos mining is about the toughest kind of digging and the satisfied customer is Asbestos Corp. Ltd., Thetford Mines, Que.

(54) HEAVY MEDIA: Bulletin from *Orefraction Inc.* outlines uses for magnetite in Heavy Media washing and separation, particularly in preparing coal for marketing. Coal preparation systems using magnetite are claimed to save time and money in cost-per-ton of finished product.

(55) SAFETY SYSTEM: *Mine Safety Appliances Co.* has a bulletin on the MSA audio safety system, an interplant or mine communications system that can be tailored to meet the needs of any installation. Shown are the microphone, message repeater, tape cartridge, controls, and a schematic diagram.

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SUPERIOR
Primary & Secondary
CRUSHER

Meets your needs TODAY and in the FUTURE!

The *Superior* crusher you install today is designed to meet your specific and immediate requirements — and it also has *built-in flexibility* to permit adaptation to future operating conditions.

Complete Adaptability

Changing the eccentric throw, crusher speed or shape of crushing chamber, varies capacity and product size. This high degree of flexibility enables you to obtain the best possible crusher operation to suit other plant equipment.

For additional flexibility, the *Superior* crusher can be fitted with *Hydroset* mechanism, a hydraulic arrangement for raising or lowering main shaft and mantle. This control facilitates emptying the crushing chamber in case of power failure or other emergencies. It also compensates for wear on concave and mantle and, when required, makes it possible for you to change product size instantly.

Write for Bulletin 07B7870

This 32-page bulletin describes the *Superior* crusher and gives you valuable crushing data. It's a book you'll want to have and keep. Ask your A-C representative for a copy or write Allis-Chalmers, Milwaukee 1, Wis.

A-4655

Superior and Hydroset are Allis-Chalmers trademarks.

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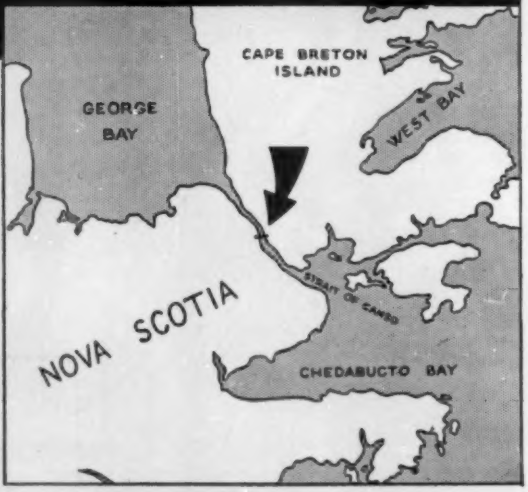
TEN MILLION TONS OF ROCK QUARRIED OUT OF MOUNTAIN TO BUILD CANADIAN CAUSEWAY



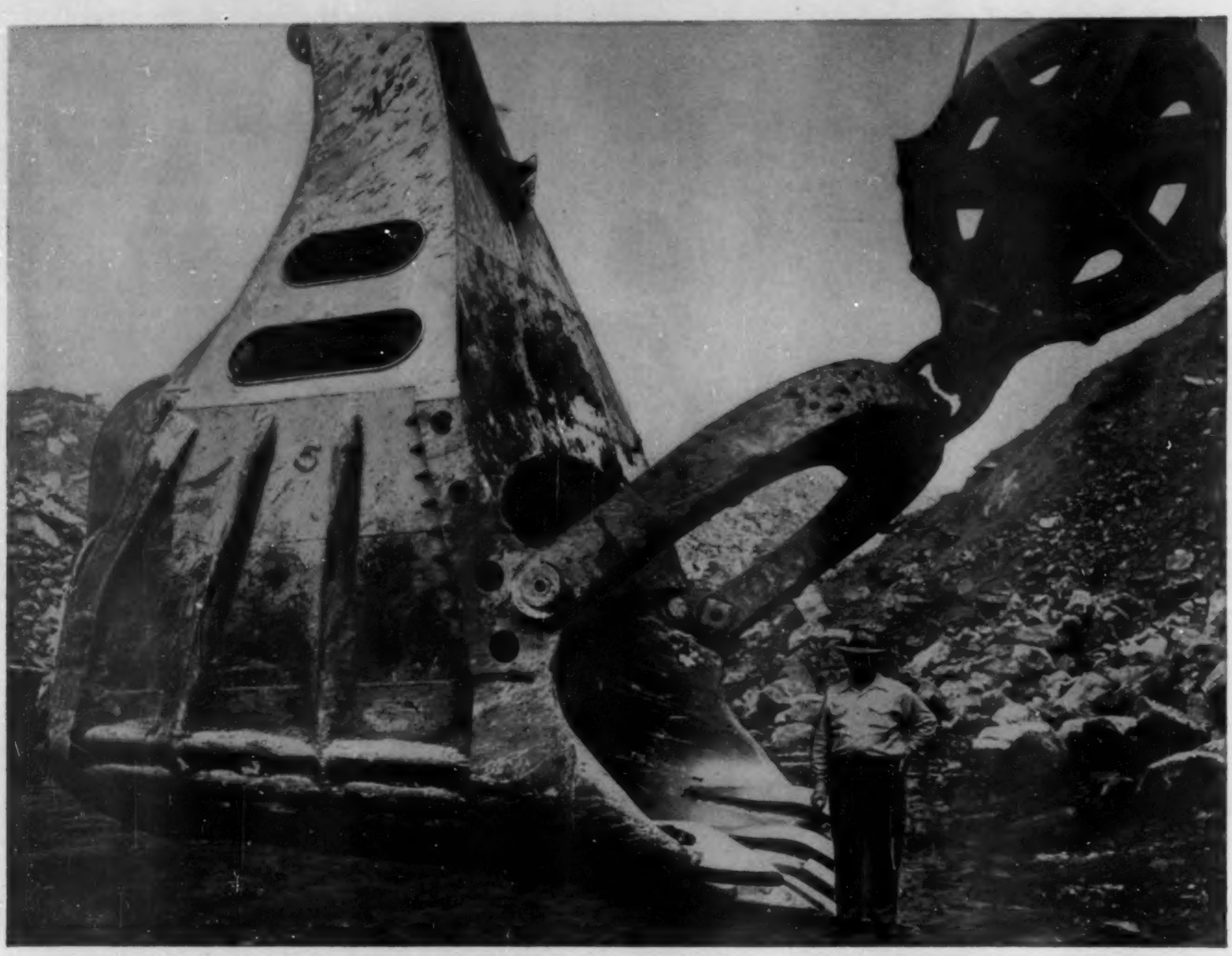
With the completion in only twenty-eight months of the three-quarters of a mile Canso Causeway, the Nova Scotia mainland and Cape Breton Island now have a new and vital link. Before its existence, all surface traffic over the Canso Straits went by ferry. Now, on a massive, dumped bed of rock quarried with the help of Atlas Copco rock drills, Sandvik Coromant Drill Steels and other equipment, a railroad track and highway have been laid, enabling trains, automobiles, and trucks to make their own way across the Canso Straits.

WORLD'S DEEPEST CAUSEWAY

Though the Canso Causeway is quite short in length, it has the distinction of being the world's deepest with a maximum depth of 210 ft. At this point, rock at the bottom of the bed had to be spread over 800 ft. Altogether, rock was required for a distance of 4,300 ft. across the Straits and for 2,700 ft. along the shore. In helping to block the great depth of the Canso Straits, Atlas Copco rock drills, Sandvik Coromant Drill Steels and other equipment, were used in one of the biggest rock-moving jobs ever undertaken in Canada.

98 TUNNELS DRILLED

By the time the Causeway had been completed, 10 million tons of rock were blasted for its construction out of the side of Porcupine Mountain on the mainland. To do this, the contractors, the Northern Construction Company and J. W. Stewart Limited, decided on the coyote-hole method of quarrying. This entails driving small tunnels, loading them



28% More Payload is carried by this 45 cubic yard "T-1" steel dipper which replaced a 35 cubic yard bucket of heavy castings. Use of "T-1" steel varies . . . from power shovels on the Mesabi Range, where temperatures drop to -50°F., to machine parts needing high strength at temperatures up to 900°F.

It's *lighter* than you think

it's made of the new nickel containing "T-1" alloy steel

THIS 45 CUBIC YARD POWER SHOVEL BUCKET shows the economy of using "T-1" steel. For here is a bucket of record size capacity, yet light enough to replace the shovel's original 35 yard dipper . . .

And after moving more than 30,000,000 tons of rock and earth, it's still going strong on the dipper stick of the world's largest shovel.

Such performance demonstrates how "T-1" steel resists both abrasion and impact.

USS "T-1" steel offers you three times the yield strength of plain carbon structural steel. Plus exceptional toughness even at sub-zero temperatures . . . particularly important to mine operators in Northern latitudes.

The properties of "T-1" steel permit you to reduce both size and weight of heavily stressed parts. Moreover, you can readily weld "T-1" steel without preheating or stress relieving. And the excellent corrosion resistance of this tough nickel containing alloy steel means increased equipment life.

"T-1" steel has proved itself in power shovels, bulldozers and mining machines. In mine cars, steel mill ladles, high speed rotating machinery and forging presses. Investigate how it may improve your products or equipment.

Get all the facts on USS "T-1" steel. Write to United States Steel Corporation, Pittsburgh 30, Pa.

INCO
TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

EJC Nuclear Congress In Cleveland December 12 to 16

Senator Clinton P. Anderson of New Mexico, chairman of the Joint Congressional Committee on Atomic Energy, will be the principal speaker in connection with the conference for management on The Place of the Atom in Your Business. The conference forms part of the Nuclear Engineering and Science Congress to be held in Cleveland December 12 to 16. Congress, to be attended by representatives of AIME and 25 other national engineering and scientific societies, is coordinated by Engineers Joint Council.

Lithium Price Cut

American Potash & Chemical Corp. reduced prices on both lithium hydroxide and carbonate for the 1956 contract year. New prices, 10¢ below previous quotation, list lithium carbonate at 82¢ and lithium hydroxide at 80¢, both in carload lots . . . **Foote Mineral Co.** kept in step by telling its customers that lithium hydroxide was now 80¢ in carload lots . . . **Lithium Corp of America Inc.** will place its South Dakota spodumene mining operations on standby basis early next year, due to development of new sources of the mineral.

Lower Prices for Titanium

Third major price reduction for titanium metal sponge was announced by Titanium Metals Corp. of America. Latest drop of 30¢ to $3.45 per lb followed two earlier reductions, one of 50¢ in April, and a 20¢ cut announced November 1. Titanium Metals Corp., only fully integrated producer in the industry, indicated that as production continues to rise there will be future price cuts aimed at rapidly expanding the civilian use of the light, but tough and strong metal.

Selenium in Short Supply, Ore Search Continues

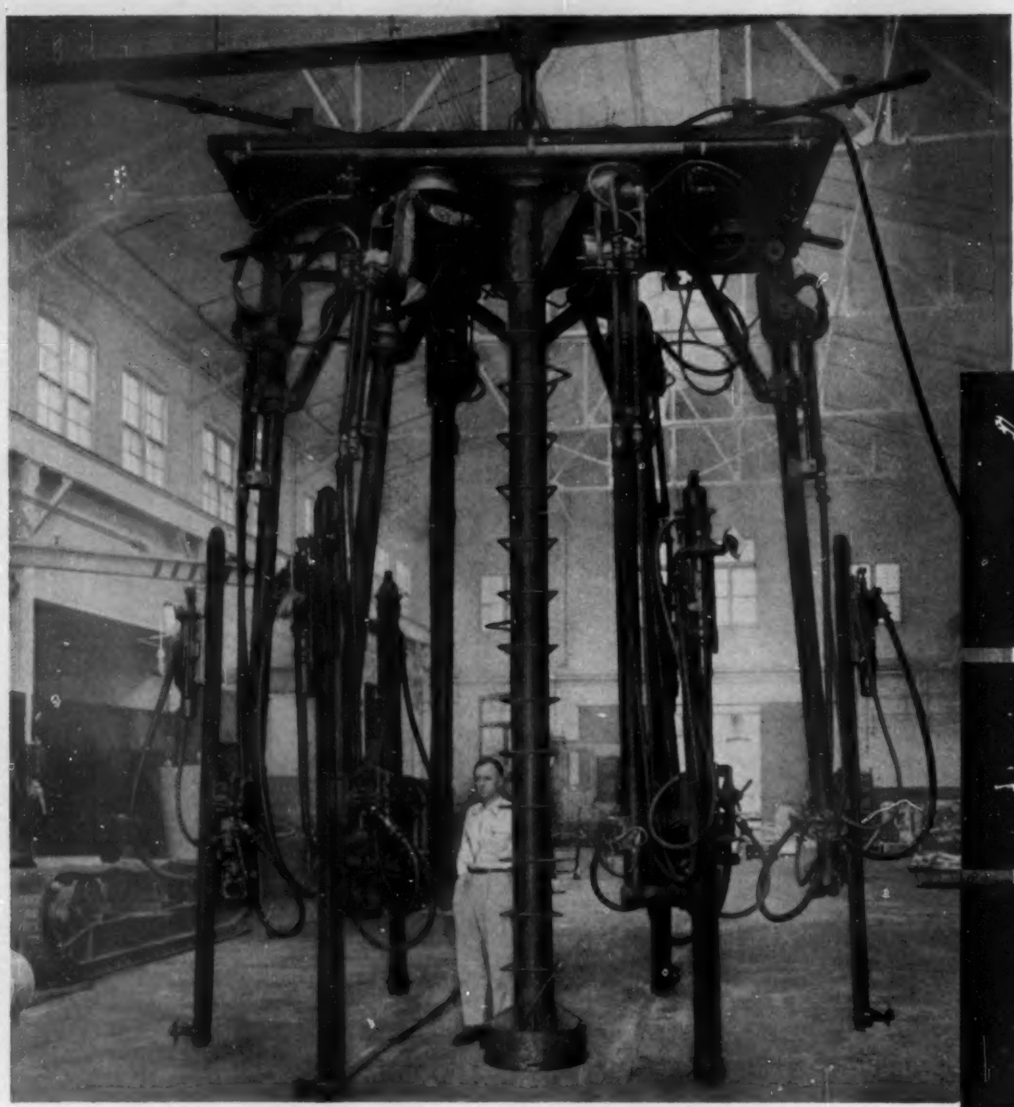
Since 1947 selenium price has jumped from $1.75 to $13.50 per lb, and blackmarket price to $40 per lb for small lots is reported. The 1954 supply of about 1 million lb, largely from byproduct sources, did not meet needs. Search is now turning to selenium ores, but ore grade of 0.05 to 0.15 pct has discouraged potential producers. Reports on search for commercial deposits in the Wyoming area have been discouraging.

Uranium Front

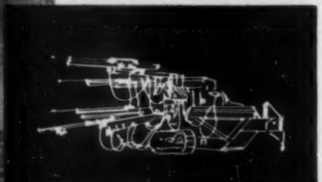
Vitro Corp. of America is to process the uranium ore output from the **Hidden Splendor Mining Co.** (Atlas Corp. subsidiary), at Vitro's Salt Lake City mill. Hidden Splendor is to ship a minimum of 5000 tons per month with option to raise shipments to 9000 tons . . . The AEC announced that the **American Smelting & Refining Co.** will cease its uranium ore and concentrate buying activities for AEC at the end of the year. Asarco has been operating eight buying stations.

Nicaro Progress Report

Edmund F. Mansure, Administrator of General Services, recently released a progress report on the Government-owned Nicaro nickel plant in Cuba. Records cited by Mr. Mansure to "factually refute the nonsense about slipshod operations at Nicaro," include: 1) production of nearly 100 million lb of nickel since plant startup in January 1952, and 2) present production at an annual rate of 31,215,000 lb, an all-time high. Target when plant was built during World War II was 31 million lb per year.

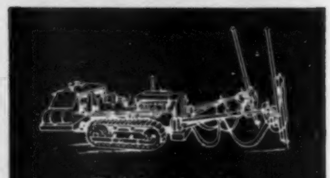


High-Face Jumbo



Crawler Jumbo

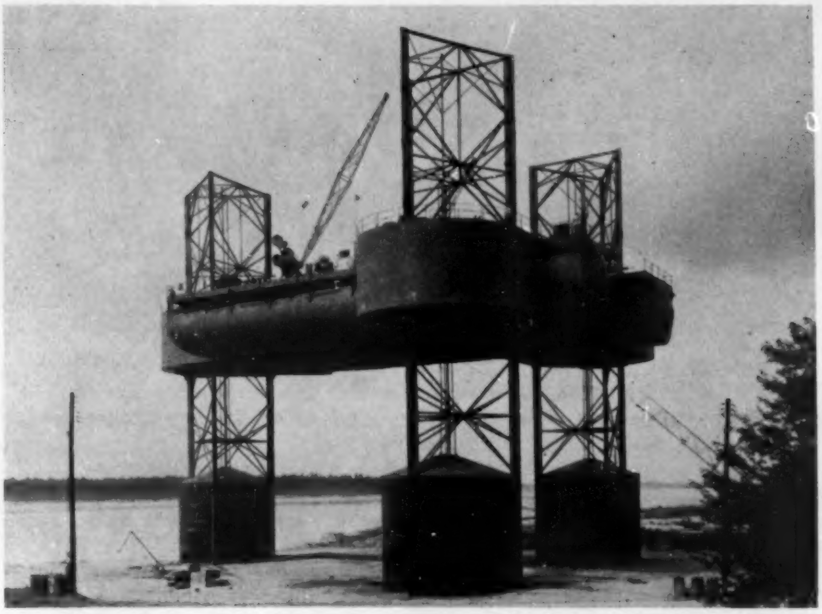
Tunnel Jumbo



Tractor Jumbo

OPEN PIT TUNNELS

View of International Nickel Co.'s Frood-Stobie open pit shows location of two tunnels which will permit rerouting of traffic and make it possible to mine additional ore by surface methods. Tunnels will take the place of sections of the main ramp road which winds around the sides of the 600-ft deep pit. Ore involved, about 5 million tons, is comprised of a large block in the footwall and a smaller block on the hangingwall.

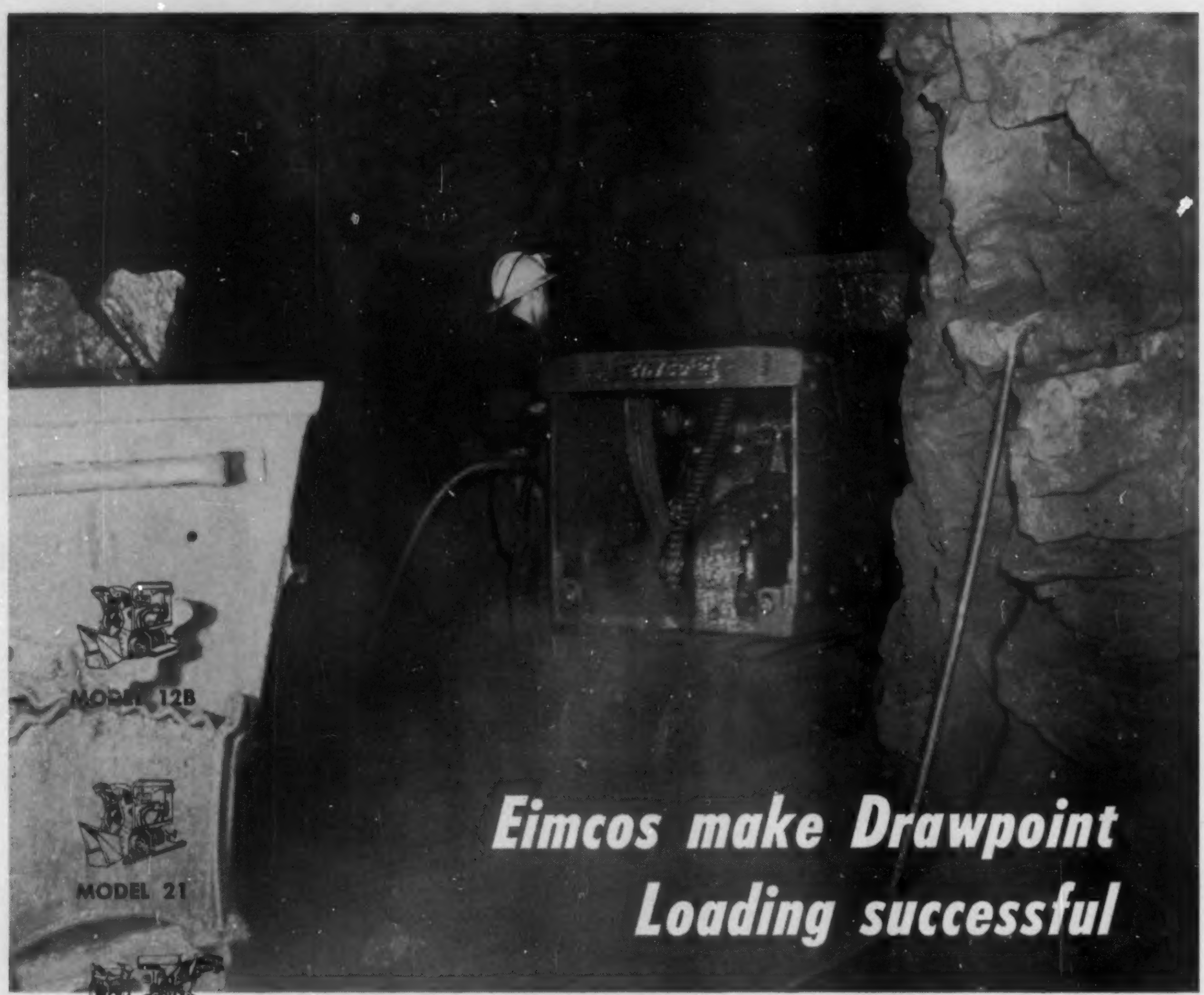


CLIMBING SKYWARD

Trying out its 140-ft legs on the banks of the Mississippi, this self-elevating platform will soon be launched and floated 400 miles downstream to the Gulf of Mexico. There it will be used as a portable *island* to reduce drilling costs in the search for offshore oil. Island was built by R. G. LeTourneau Inc. at a plant near Vicksburg, Miss.

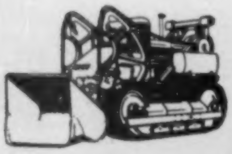
GIANT WALKS THE EARTH

In the process of traversing Highway 64 this Marion 7400 dragline (ordinarily used by Saxon Coal Corp. for coal stripping) draws an audience. Two Caterpillar electric sets in semi-trailers provided power for the 7-mile journey from Somerville to new mining area at Oakland City, Ind.



MODEL 40H

MODEL 630



MODEL 105

Most mining companies around the world are now using some type of drawhole loading, or are actively investigating its application for some spot in their operations.

No other method of production loading underground has provided a way to increase man's productivity, to develop an area so quickly or at a comparable low cost, to save time in drilling and money in powder and, to permit men to work with greater safety.

Chutes and grizzlies are too expensive to install, maintain or use in modern day mining.

The Eimco loading machine has helped make this method of production possible. The rugged construction, its ability to work year in and year out with an extremely low cost of less than a cent per ton loaded, make it mandatory that cost cutting with drawpoint loading will include Eimcos for the loading equipment.

The thousands of Eimcos in use today are being joined by some additional models. Each machine is designed to meet specific requirements so that there is an Eimco loader that will handle your loading job to your complete satisfaction. Eimco will be glad to send you information on loading from drawpoints that has been gathered from mines in many areas. Write for bulletin L1017.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Baltimore, Md. Pittsburgh, Pa. Seattle, Wash. Pasadena, Calif. Houston, Texas Vancouver, B. C. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

B-164

Tar Production May Help Bring New Era for Lignite

The chemical industry has a new raw material. A long list of new and known products may evolve from this material, the low-temperature tar derived from carbonization of lignite at Aluminum Co. of America's plant near Rockdale, Texas.

It is known that low-temperature lignite tar contains valuable chemical compounds, but utilization for chemical purposes has not been economically practicable to date because the tar has not been available in commercial quantities.

Alcoa's four potlines at Rockdale not only add 90,000 tons per year to the nation's aluminum capacity, but also make possible research and utilization of lignite tar. Here dried lignite and carbonized lignite are used for the first time in this country as a fuel for generation of power in making aluminum.

Dragline excavator is shown stripping overburden from lignite deposit near Rockdale Works. This 35-cu yd electric dragline has a 220-ft boom.

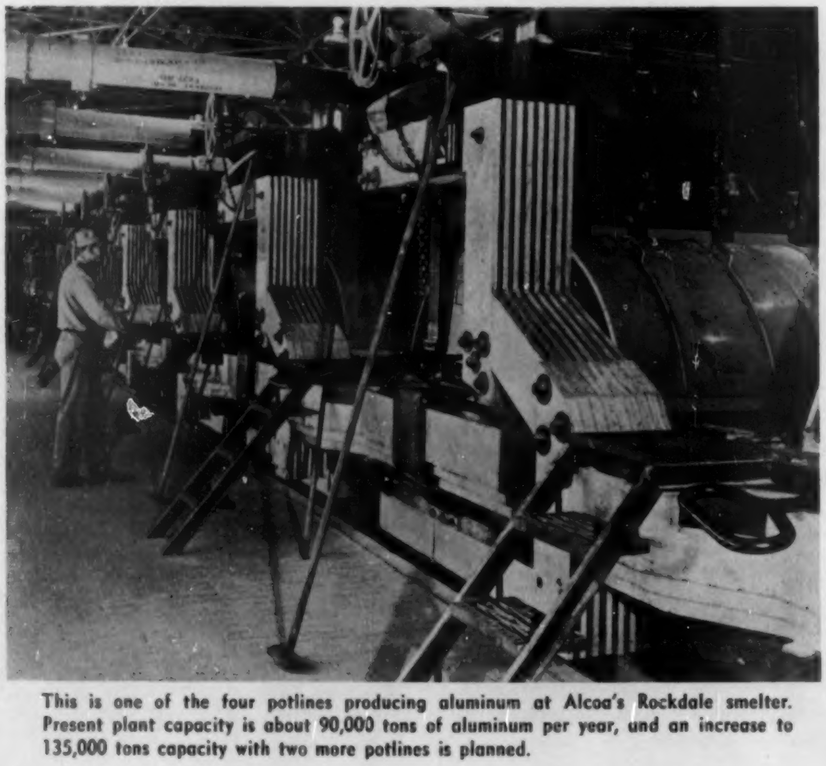
Lignite for Power

Existence of large deposits of lignite in Milam County, Texas, had been known for years, and feasibility of using this material as a power source was proposed by Texas Light & Power Co., which had sponsored investigation of lignite technology in cooperation with the USBM laboratory at Denver.

Alcoa announced its plans for an aluminum plant at Rockdale, Texas, in 1951 and by 1954 all four potlines were in production. Further expansion plans were revealed recently.

All power requirements are generated on the site at the 80,000-kw Sandow power plant which is owned by Alcoa and operated by Industrial Generating Co., an affiliate of Texas Light & Power Co.

Selection of the Texas town as an aluminum plant site made news in 1951, but selection factors were simple. The Milam County lignite fuel, only slightly superior to peat, has low heating value, and relatively high ash and moisture contents. To take full advantage of low fuel cost the plant had to be close to the deposits to reduce transportation.



This is one of the four potlines producing aluminum at Alcoa's Rockdale smelter. Present plant capacity is about 90,000 tons of aluminum per year, and an increase to 135,000 tons capacity with two more potlines is planned.

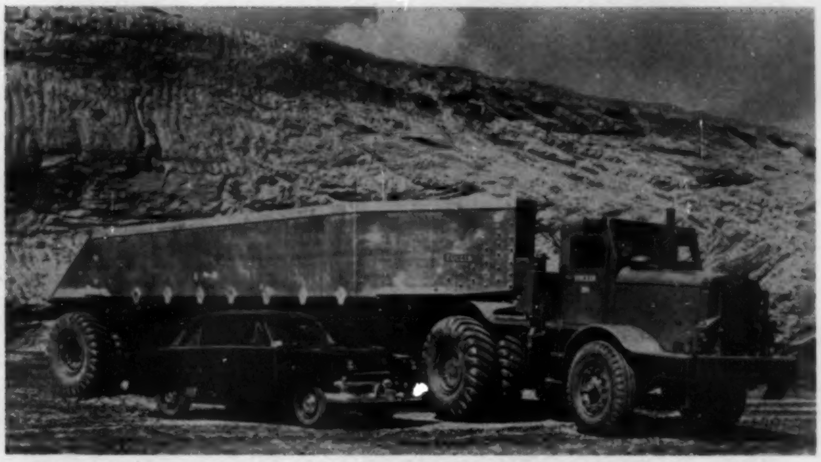
Lignite Moves by Conveyor

Lignite is carried over a long belt conveyor system stretching from the two crushing stations at the stripping operation to the handling system at the Sandow power station. The entire system, including the eight-flight, 3½-mile conveyor line was engineered, built, and installed by the Link-Belt Co.

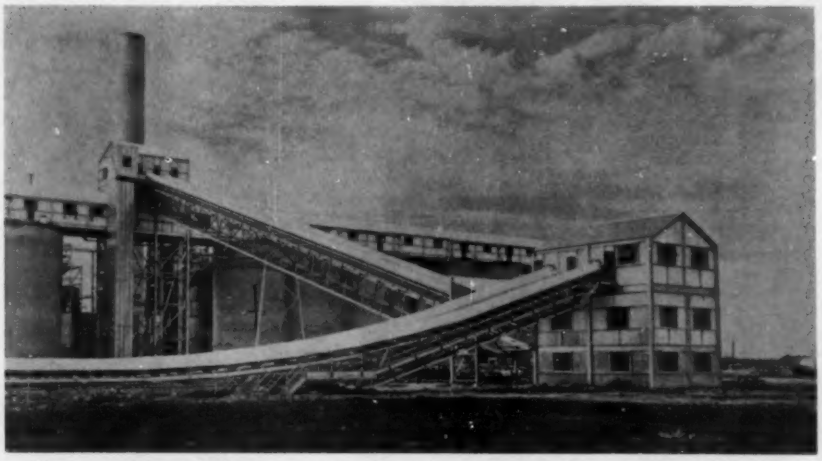
The Tar Product

At Rockdale a prototype carbonizer and tar recovery unit capable of producing 16,000 gal of lignite tar per day has been built. A research and utilization program based on this new and relatively unknown material is co-sponsored by Alcoa and Texas Light & Power. Research on the tar is being carried out by Battelle Memorial Institute.

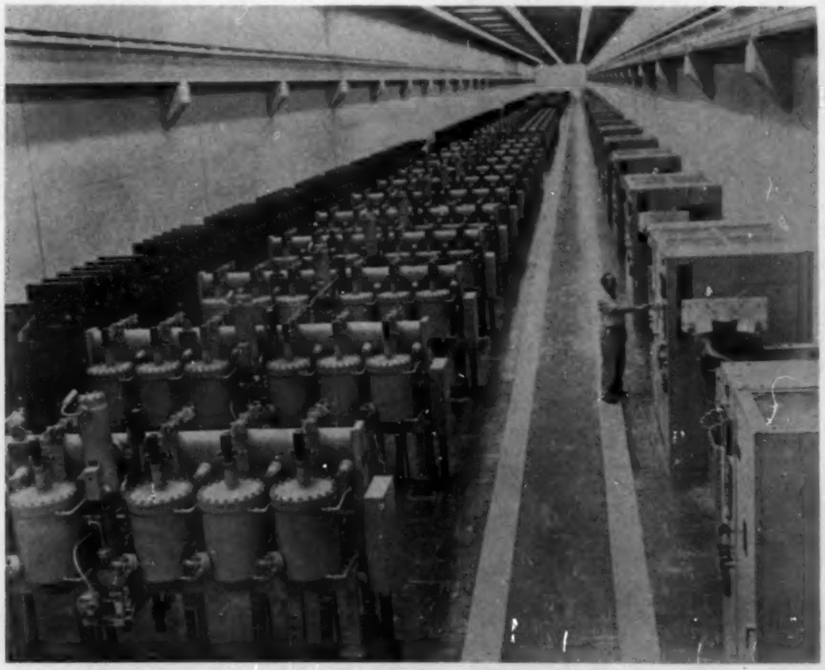
Nine companies are participating in the research and utilization program, but tar products not purchased by these companies will be made available to other firms. Samples of materials at present available and specifications on the product may be obtained from the marketing agent for the material, Texas Light & Power Co., P.O. Box 6331, Dallas 22, Texas.



One of the seven trucks that haul lignite to the conveying system. The aluminum alloy trailer bodies of these trucks have 61-cu yd capacity.

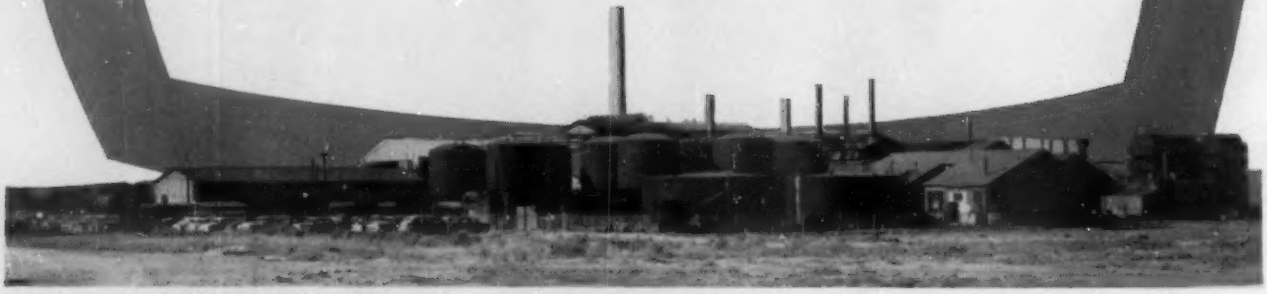


Lignite conveyors leading to raw lignite storage bins. Conveyor system totals 3½ miles in eight flights between the crushing plants and the storage area.



Rectifier station converts alternating current to direct current for use in the Rockdale potlines.

National Zinc selects a FluoSolids* System



Two Dorrco FluoSolids Reactors were installed early in 1954 at the Bartlesville, Oklahoma, plant of National Zinc Company. Placed on the foundations of two roasters which they replaced, the Reactors deliver an 11% SO_2 gas to a contact acid plant and a calcine of controlled sulfur content for sintering prior to retort zinc production. In addition to its metal production, National Zinc is an important supplier of sulfuric acid to the Southwest area, producing 72,000 tons of H_2SO_4 yearly.

Positive advantages of the FluoSolids System at Bartlesville are:

Roasting capacity increased 25% using same plant space . . . acid plant requirements now met without use of supplementary sulfur burner.

Improved sintering product due to closely controlled sulfur content in calcine.

Variety of flotation concentrates for custom smelter are handled without complicated adjustments to changing feed conditions.

No need for extensive grinding or drying . . . System handles feed in slurry form . . . no further grinding of flotation concentrate is required.

No extraneous fuel needed as burning is self supporting once ignition temperature is reached.

High strength SO_2 produced from feed containing 31% sulfur . . . average gas analyzes 11% at the stack.

If you'd like more information on Fluidization . . . the most significant advance in roasting techniques in the last 30 years . . . just drop a line to Dorr-Oliver Inc., Stamford, Connecticut or in Canada, 26 St. Clair Avenue East, Toronto 5.

FluoSolids is a trade-mark of Dorr-Oliver Inc. Reg. U.S. Pat. Off.

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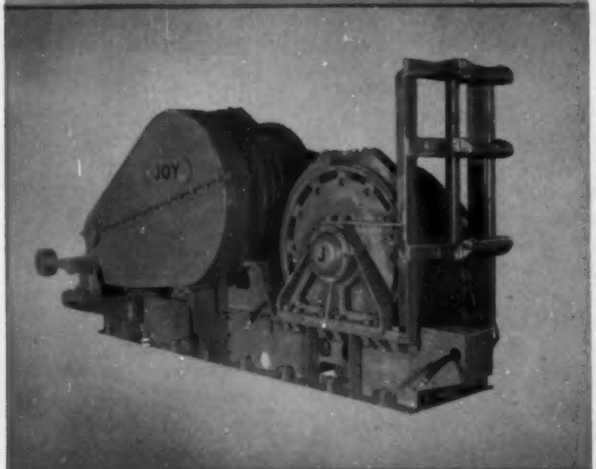
One of each size

5HP—The S-211, the Mighty Mite of the Joy Slusher Family.



150 HP—For rugged, heavy-duty operation, you'll never beat the giant Joy XT-221 Slusher.

The JOY *Complete* Family of Slushers

From the Mighty Mite . . . the S-211 . . . to the giant XT-221 is a big jump but there are many, many rugged, efficient sizes of Joy Slushers in between that bridge the gap smoothly, completely. You're sure to find one sized exactly right for your job. Here's a representative list:

5 HP—S-211
7½ or 10 HP—FF-211 and FF-311
15 to 25 HP—A2F-211 and A2F-311
20 to 40 HP—B2F-211 and B2F-311
30 to 75 HP—C2F-211 and C2F-311
100 and 125 HP—R-221, RF-211 and RF-212
150 HP—XT-221 and XT-222

All of the more than 300 types and sizes of Joy Slushers have these features which assure low maintenance and operating costs: Large drum diameters for longer rope life; easily removable clutch bands; simple, rugged construction; special water-proof, dirt-proof bearings; and rugged steel frames.

Remember, there is not a scraping job anywhere that can't be efficiently handled with a Joy Slusher. Consult a Joy Engineer for the size and type best for your scraping job. ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario*

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JOY

WORLD'S LARGEST MANUFACTURER OF UNDERGROUND MINING EQUIPMENT

DIVERSIFICATION as a business principle is getting more than lip service from the mining industry. Climax Molybdenum, New Idria Mining & Chemical Co., and many others have been taking long strides in the direction of a broader base of operations. Last month Cerro de Pasco Corp. announced plans to purchase the assets of Circle Wire & Cable Corp. of Maspeth, L. I., for $20.25 million. Cerro is to assume certain additional liabilities and final approval of the deal depended on a November 28 meeting of Circle stockholders.

This purchase would give Cerro de Pasco a subsidiary manufacturing more than 100 separate wire and cable products used for lighting, heating, and power applications in both industrial and residential construction. Average annual sales of Circle products over the past five years have exceeded $19 million. Circle's main factory at Maspeth, L. I., serves as company headquarters and the firm's other plant is at Hicksville, also on Long Island.

The prospective purchase is an outgrowth of a policy aim set several years ago. The goal is broad geographic and product diversification. Previous steps taken by Cerro de Pasco in furthering these ideas include:

► A $50 million zinc development program initiated in Peru in 1951.

► A 16 pct participation in the Southern Peru Copper Corp. which has a $200 million program underway in Tacna Province. The ore reserves there are reputed to be among the largest in the world.

► Acquisition of 45 pct ownership in a Peruvian company producing wire and cable for the local market.

► Acquisition of a 40 pct interest in a Peruvian firm which is to manufacture refractory brick.

► Participation in the organization of another Peruvian firm which will produce industrial explosives.

► Preliminary prospecting for oil in the eastern Peruvian jungle.

► Continued oil and gas exploration on a limited scale in the U. S.

The same sort of goals were well expressed in the latest annual report of New Idria Mining & Chemical Co. C. Hyde Lewis, president of the company, put it this way in his letter to the stockholders.

"During the past year, your company has been among the many leading American business and industrial enterprises which are recognizing diversification as the key to continuing success and prosperity.

"By diversifying our operations, we have insured maximum utilization of the experience and know-how of our management team. We have created a potential for a continuity of earnings, production, and employment which could not have been achieved through any single specialized activity.

"We regard our entry into tungsten and uranium mining as the most significant development in the history of the New Idria Mining & Chemical Co."

Until now New Idria's fortunes have been tied to quicksilver. Few materials have had such a history of drastic and often unexpected price swings. Tungsten has not had the most uniform production history, but uranium offers a guaranteed price on which to base operations until 1962.

Mr. Lewis feels, however, that three metals—mercury, tungsten, uranium—offer the company a far better chance of continuity than just one mineral product. Further stability for New Idria comes through its subsidiary, Metalsalts Corp., a manufacturer of mercurial compounds. It seems likely that New Idria will not rest at this point. The diversification bug has bitten.

▲

WOMEN engineers are here to stay. These defiant words were handed down at the diamond jubilee annual meeting of the American Society of Mechanical Engineers. The authority was Dot Merrill, owner of the Chicago engineering sales firm that bears her name.

Mrs. Merrill said that there are about 4000 women professional engineers today, more than five times as many as there were in 1940. These women, moreover, often exceed the average requirements for men, while "engineering schools report that the majority of women enrolled are above the class average scholastically."

Women engineers seem to be accepted particularly in the aviation, electrical, and electronics equipment industries. According to Mrs. Merrill almost every engineering course admits women.

She referred to a Dept. of Labor bulletin that minimizes the physical exertion of engineering jobs other than those involved in "military service under combat conditions."

To this, Mrs. Merrill added:

"I am much better equipped to climb through the manhole of a boiler drum or into its furnace to make an inspection than most of the oversized boiler inspectors I know. I can do it in half the time, too."

Dot Merrill & Co. came out in 1947. Firm's symbol is a silhouette of a woman with an old-fashioned rolling pin.

▲

THE prospector is still on foot. So readers are reminded by a bulletin from the Alaskan Territorial Dept. of Mines. The item goes on to point out that many people have been misled to believe that the upsurge in airborne prospecting means the end of the man on foot as the discoverer of ore. Almost the opposite may be true if exploration activity continues as it has in recent years. The trouble is that the instruments in the plane cannot tell, no matter how sensitive they are, just what the anomalies reported from the ground mean in terms of ore. As the TDM bulletin puts it: "All the fancy

gear in existence will not fully take the place of a good prospector patiently examining the country on foot. On the other hand, a prospector will have greater chances of success when working in an area where aerial work has disclosed above-normal radioactivity."

While the foregoing relates specifically to uranium prospecting in Alaska, the thought seems to have considerable validity when looking for anything, anywhere.

▲

APPLIED research was a professor's spare-time activity until 1862. That was the year the Dept. of Agriculture was established. The first U. S. school to recognize graduate research as a major function was Johns Hopkins, founded in 1876. However, industry did not organize laboratories until this century. The General Electric laboratory was started in 1900, but there were only about 100 industrial laboratories by 1915. There are more than 3000 now.

Growth is not the only observable trend in industrial research. Search for a solution to the shortage of genius has led more recently to the idea of teamwork as a primary aid to meet technology's ever-increasing complexity. Everything from football to politics benefits from teamwork—why not industrial research?

"But for a long time," says Clyde Williams, president of Battelle Memorial Institute, "it was heretical to think formally of using groups of specialists to attack research problems. This would kill individual initiative and professional development, it was thought. . . . It took some outstanding examples of successful group research, and pressure from industry for higher efficiency in research, to dispel these notions. The tremendous success of the Manhattan Project during World War II in using the combined efforts of thousands of scientists to develop the atomic bomb finally proved conclusively the efficacy of cooperative effort. Now, all modern laboratories use teams of scientists in attacking problems. . . . We can now compress into a few years the technological development that would otherwise have required decades—perhaps even a half century."

▲

AN example of team research with parallels to the rest of the mineral industry comes from the solution of a problem in the oil fields. Drillers in the Permian Basin fields of west Texas ran into trouble with drill pipe breakage several years ago. The American Assn. of Oilwell Drilling Contractors came to Battelle with the problem. Specialists soon found that pipe failure was due to corrosion fatigue, caused by the peculiar drilling conditions of the area.

Once the source of the trouble was isolated a host of other specialists took up the various aspects suggested by the known facts. Chemists studied means of combatting corrosion, metallurgists turned to better materials or new coatings for old materials, while mechanical engineers and physicists devised operating procedures that would reduce stress concentrations in the drilling string, and electrical engineers and testing experts developed field procedures for revealing fatigue cracks before they caused failure.

The final result of the study, a set of drilling practice recommendations, was available within ten months of the start of the project. Soon after these were adopted by the contractors, drill-string failure ceased to be a problem in the Permian Basin. The research cost the drillers' association $20,000. Teamwork had come up with an answer to a problem that might have taken one man a lifetime to define, let alone solve. And, the entire costs of the project were saved in less than a week of normal drilling operation.

The parallel from this situation in the oil fields to many problems in the mining field is undoubtedly to be found. But, there is some probability that the most costly problems are never recognized as such —they are part of the accepted operating difficulties. Unless a problem is new, or dramatic, it may never be recognized as a proper subject for what the atomic scientists have named a *crash* program.

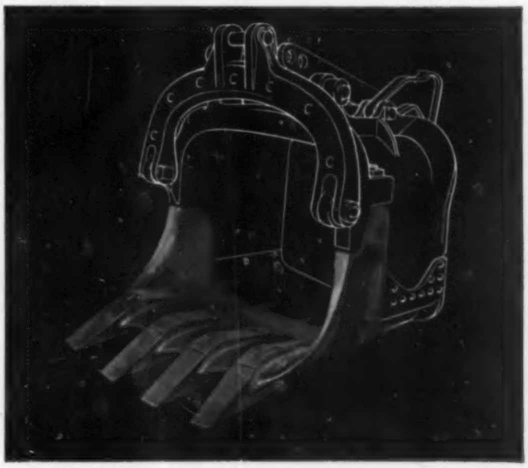
▲

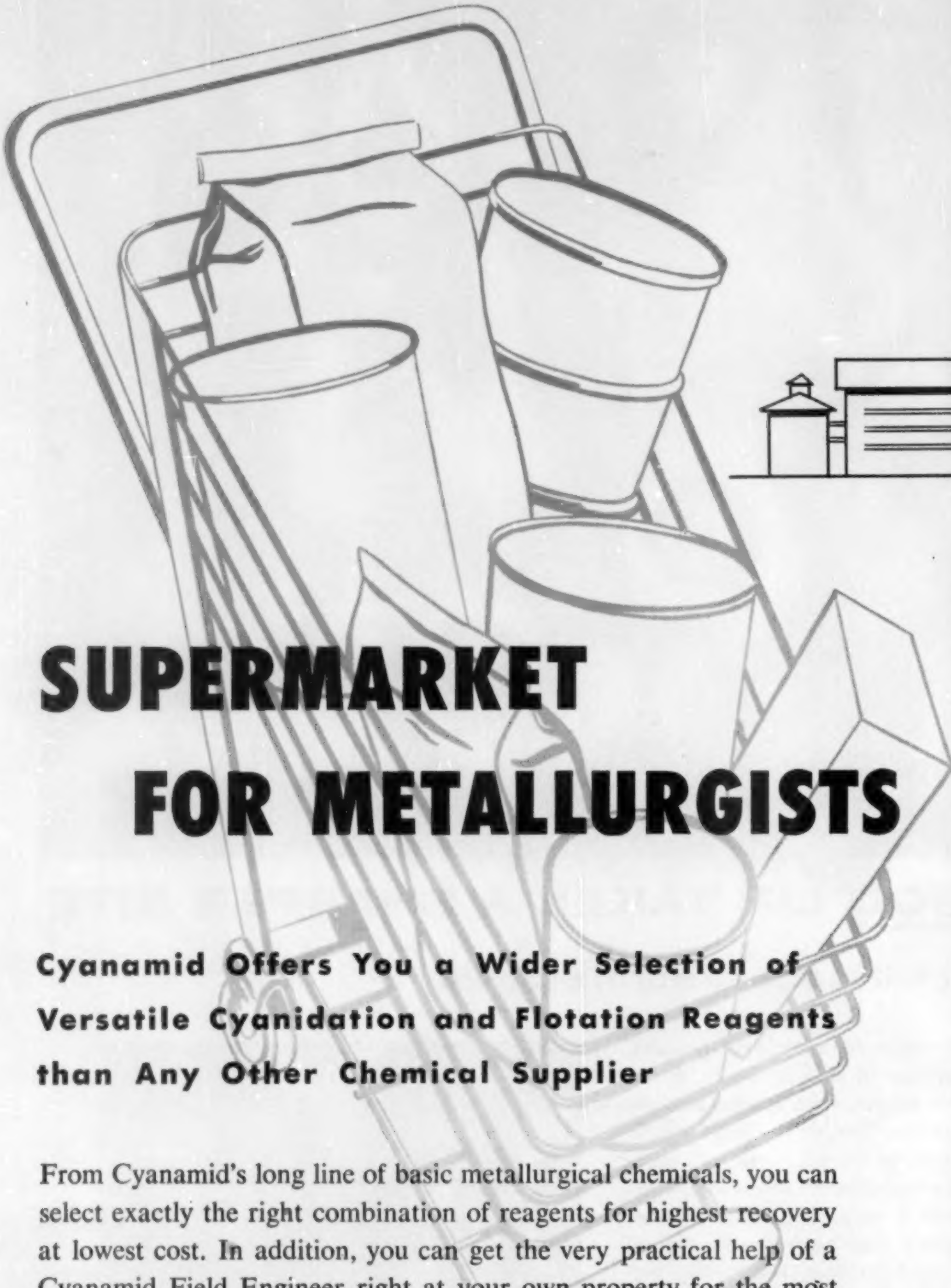
ENGINEERING education is receiving positive action in at least two quarters. Steps in the right direction were taken independently by Jones & Laughlin Steel Corp. and the University of Pennsylvania. Announcing a $115,000 a year program of aid to education, company president C. L. Austin said, "We at Jones & Laughlin recognize the financial problems being faced by educational institutions today."

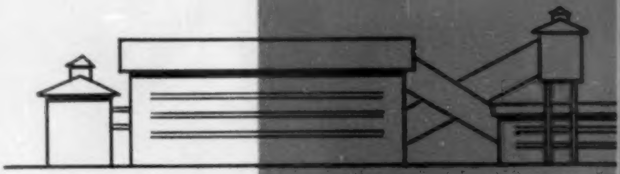
During the same week The University of Pennsylvania reported it was able to accommodate 50 pct more well qualified engineering students than are now enrolled. The increased enrollment capacity was made possible through a modernization of curricula and facilities. Present enrollment is about 1200 in chemical, civil, mechanical, electrical, and metallurgical engineering.

In the modernization of curricula, more emphasis has been placed on analytical studies and the humanities and less on shopwork and drafting, making certain facilities available to more users.

Completion last year of the university's physical sciences building has enabled the physics and mathematics departments to teach those required subjects to more engineering students. Fuller use is being made of other buildings and facilities.







MINING engineering

DRIFT

Dear Boss: Would it be possible for me to have time off to attend the Annual Meeting in February? I've seen a list of the papers and I don't want to miss them.—Bob

Dear Bob: Chief says it's *completely* impossible. He says most of the papers will be published in MINING ENGINEERING later on. I tried to convince him that all the 300 and more papers couldn't be published there, but you know the Chief.—D.C.J.

P.S. Chief wants to know how you got the idea on that safety device you installed on the 1100 level.

Dear Boss: Safety gismo came from a friend at the AIME Meeting in Chicago.—Bob

Dear Bob: Send copy of friend's paper at once. Chief going to Greece and wants to take it with him.—D.C.J.

Dear Boss: It wasn't a paper. I just happened to run into the fellow and he told me how Cleveland-Cliffs had handled it up in Michigan. Enclosed blueprint shows how we did it.—Bob

Dear Bob: Thanks for your report. Chief would also like data on that concreting job at No. 4. Please send material at once.—D.C.J.

Dear Boss: Idea on that job came from an unpublished discussion on concreting at Climax at the 1954 Annual Meeting in New York. Here's the dope as near as I can remember it.—Bob

Dear Bob: Chief now says it's O.K. for AIME Meeting, but company can't afford to pay your expenses. I tried to make him see that the company couldn't afford not to. He wants info on that grouting machine attachment Jeffrey is using.—D.C.J.

Dear Boss: Have no info on grouting attachment. Paper on it to be presented at Annual Meeting. No copies available yet.—Bob

Dear Bob: The second you get your hands on that report air mail it to Greece. Chief has O.K.'d your expenses to AIME Meeting as our representative. I tried to talk him into paying for Jane's trip too, but he can't see how wives have any value at a technical meeting. I told him wives just double contacts, but you know him.—D.C.J.

Dear Bob: Chief wants address of that Greek geologist you introduced him to. Send it at once if you've got it.—D.C.J.

Dear Boss: Have only the old address in Calcutta. Have you checked AIME?—Bob

Dear Bob: Institute hasn't received new address. See if there's some way you can get it. Chief wants it at once. Spare no expense!—D.C.J.

Dear Boss: Have cabled Chile, telephoned Mexico City and Paris. No luck. Now have call in for Melbourne.—Bob

Dear Bob: Call me any time day or night that you get that Greek geologist's address. Chief has called three times today from Athens.—D.C.J.

Dear Bob: Sorry to have been so abrupt with you on the phone, but the chief was on the other line. How in the hell did you get that address?—D.C.J.

Dear Boss: Jane just happened to get a letter from the Greek geologist's wife that morning. They met at the AIME Meeting in San Francisco. That's how he and I met—through our wives.—Bob

Dear Bob: In case you're interested, it's raining in Athens today. Long call from the boss and he was sure happy to get in touch with your geologist friend. He lives only two blocks from the Chief's hotel.

Chief is sending Jane and you to the AIME Meeting—all expenses paid. Merry Christmas from the firm! Chief also wonders if Jane and you wouldn't like to take that cruise to Bermuda and Nassau too. —D.C.J.

Defense Mineral Policies and Programs Of the U.S. Government

by John D. Morgan, Jr.

PRIOR to World War I there was no Government stockpiling program. Prior to World War II relatively few items were included in Government stockpiling and the start of that war found most objectives for even these few materials far from complete. Profiting from the experience of materials shortages in two wars, Congress in 1946 passed the Strategic and Critical Materials Stock Piling Act, which stated that it is the policy to decrease and prevent wherever possible a dangerous and costly dependence of the U. S. upon foreign nations for supplies of strategic and critical materials in times of national emergency. However, as of mid-1950 few stockpile objectives had been achieved.

Shortly after the start of the Korean War it was obvious that in the absence of adequate stockpiles, the defense program could not be successfully carried out without broad authority to expand supplies of strategic and critical metals and minerals and at the same time to channel limited supplies of these materials to essential defense purposes. Accordingly, in September 1950 Congress passed the Defense Production Act, which provided broad powers for allocating materials and for making arrangements, including financial, to expand supplies.

In October 1953 the President established a Cabinet Committee on Mineral Policy. The chairman of the committee was the Secretary of the Interior and the members were the Secretaries of State and Commerce and the Director of the Office of Defense Mobilization. The Secretary of the Treasury and the Director of the Bureau of the Budget were consultants. The committee was requested to observe three major considerations:

1) To insure that the U. S. has available mineral raw materials to meet any contingency during the uncertain years ahead.

2) To insure that the U. S. can meet the ever-growing mineral requirements of an expanding economy.

3) To preserve the added economic strength represented by recent expansion of facilities by the domestic mining industry, through policies that would be consistent with other U. S. national and international policies.

J. D. MORGAN is Mineral Expert on the staff of the Office of Defense Mobilization, Executive Office of the President, Washington 25, D. C. Opinions expressed are those of the author and do not necessarily reflect official views.

Because in the past the lack of available metals and minerals has proved a weak link in American security, several recommendations of the Mineral Policy Committee dealt with security needs, including maintenance of the mobilization base, establishment and acquisition of new long-term stockpile objectives for metals and minerals, and better and closer Government-industry relations. The *Report of the President's Cabinet Committee on Minerals Policy—November 30, 1954* was issued only after discussion at several meetings of the Cabinet and final approval by the President himself. Many recommendations of the *Report* have already been put into effect and others are being carried out as quickly as possible.

Strategic Stockpile Program

Stockpile objectives are determined by comparing estimated wartime requirements for materials with estimated wartime supplies. Wartime requirements, which cover a projected period of several years, can be divided into five major classes: military, atomic energy, essential industrial, essential civilian, and essential exports. Wartime supplies can be divided into three major classes: domestic production (including secondary material where appropriate), imports from nearby sources, and imports from distant and relatively inaccessible sources. Minimum stockpile objectives are calculated by reducing wartime supply estimates by certain safety factors which provide for estimated shipping losses, political instability in foreign countries, and the danger of relying on concentrated sources.

The official list of materials shown in the table, shows that of the 75 materials, 55 are metals and minerals. At the present time, minimum stockpile objectives are valued at about $7.0 billion and materials actually on hand at more than $4.7 billion; thus the minimum stockpile is about two thirds complete on an overall basis. This percentage varies, of course, from one material to another. For example, the minimum objective for tin has been achieved while those for some other materials, such as nickel and mica are still far from being met. In general, it is Government policy to try to achieve minimum objectives as quickly as possible. Stockpile objectives for all materials are reviewed from time to time and revised upward or downward as indicated by changes in requirements and supply estimates. Materials in the stockpile can be released only on order of the President when required for purposes

OPEN STORAGE OF SEVERAL METALS AND ORES AT A STOCKPILE DEPOT. MATERIALS ARE STORED AS CLOSE AS POSSIBLE TO CONSUMERS TO STOCKPILE TON-MILES OF TRANSPORTATION AND TO AID CONTINUITY OF PRODUCTION DESPITE DISRUPTION OF TRANSPORTATION FACILITIES IN WARTIME. NOTE THAT PROVISION IS MADE FOR READY ACCESS BY TRUCK AND RAIL. AS MUCH AS ONE MILLION TONS OF ORE MAY BE STORED IN ONE PILE, OR, IN SOME CASES, AS LITTLE AS 20 TONS.

of the common defense or during a national emergency with respect to common defense.

On Mar. 26, 1954 President Eisenhower announced that he had authorized the Office of Defense Mobilization to revise the stockpile program by establishing new *long-term* mineral stockpile objectives, which when added to the minimum objectives, bring the total ultimate value of the stockpile to about $10.4 billion. Materials valued at about $5.6 billion are already on hand and commitments in effect make substantial provision for completion of many objectives.

The President stated that wherever possible, in accordance with criteria noted below, strategic and critical metals and minerals in the stockpile should be upgraded to the point at which they will be more readily usable in the economy in the event of emergency. For example, about 4 tons of bauxite are required to make 1 ton of aluminum metal. Thus stockpiling aluminum metal will also serve to stockpile transportation, electrical power, manpower, facilities, and time--all expected to be short in the event of a future war. Many of the stockpile materials such as copper, lead, zinc, and tin are already in metal form, but specifications for other materials are being reviewed to determine where upgrading should be undertaken.

Metals and minerals for the increment between minimum stockpile objectives and the long-term objectives are acquired ordinarily at such times as the Government decides that purchases will also serve to maintain essential elements of the mobilization base. Consequently preference is given newly mined metals and minerals of domestic origin. In addition, materials are acquired in exchange for surplus agricultural commodities or by transferring to the stockpile metal and mineral surpluses accumulated under other Government programs. In making purchases the normal channels of trade are fully utilized to avoid disruption of the normal producer-consumer relationships in the U. S. and in friendly foreign countries.

Expansion Programs

Under the Defense Production Act of 1950, commitments approximating $5 billion have already been made to expand supplies of metals and minerals for defense purposes. Among the major programs launched under this authority is the aluminum program, in which U. S. annual productive capacity has been doubled from its pre-Korean level of about 800,000 tons a year. In the case of copper, nearly a billion dollars in long-term market guarantees have resulted in the expansion of several major

domestic copper properties such as the San Manuel deposit in Arizona and the White Pine mine in Michigan. These and other properties are expected to increase U. S. domestic mine production of copper by about 250,000 tons a year when full production is reached.

More than a half billion dollars have been committed to increase the production of nickel, while hundreds of millions have also been obligated for each of the following: manganese, molybdenum, and tungsten. Lesser sums are involved in expansion of many other materials including asbestos, chrome, cobalt, columbite-tantalite, fluorspar, graphite, lead, magnesium, mercury, mica, and zinc.

Titanium production has already been increased from a few tons prior to the Korean War to an anticipated 1955 production of 10,000 tons. More will result in future years from the present expansion program involving nearly a billion dollars. Although titanium is heavier, than aluminum, it is also much stronger, can stand considerably higher temperatures, and is highly resistant to corrosion.

Recent amendments to the Defense Production Act, approved Aug. 9, 1955, provide clear authority to make appropriate provision for meeting defense needs by developing (through research or other means) substitute materials that could alleviate shortages of critical materials. For example, development of certain synthetic abrasives might well reduce U. S. dependence on supplies of natural diamonds; development of certain substances possessing high dielectric properties could reduce dependence on natural mica; and development of certain ceramic materials or special alloys could reduce the need for nickel in high temperature applications.

Tax Changes Encourage Domestic Expansion

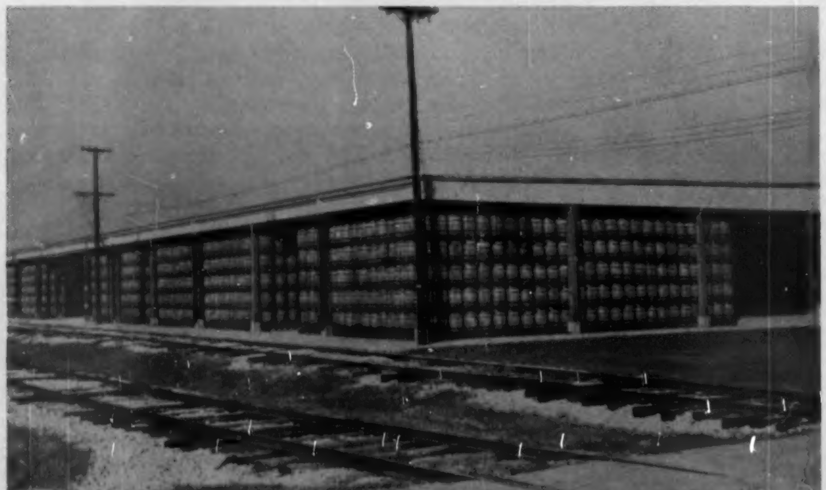
Under the Revenue Act of 1950 it had been possible to grant accelerated tax amortization to aid in expanding the operations of many producers of metals and minerals. This authority is continued by the Internal Revenue Code of 1954. With accelerated tax amortization, nearly $2 billion in expansion of metal and mineral production has been undertaken since the start of the Korean War. Steel is a major industry where expansion has taken place almost entirely by private financing with the assistance afforded by accelerated tax amortization. Current steel capacity is about 126 million tons a year compared to World War II capacity of about 85 million tons a year. Consequently over 40 million more tons of steel are available for either current industrial use or defense production.

Under the Revenue Act of 1950 it was possible to exempt from the excess profits tax domestic production of certain strategic and critical metals and minerals previously not produced in appreciable quantity within the U. S. This assistance has resulted in a major increase of domestic production of the rare earth minerals (which include cerium, neodymium, lanthanum, and several other extremely rare elements) whereas only a few years ago the U. S. was almost wholly dependent on foreign sources such as Brazil and India.

Under the new Internal Revenue Code of 1954 the list of materials entitled to percentage depletion was enlarged and clarified, and for almost all strategic and critical metals and minerals the percentage allowed has been raised from 15 to 23 pct. Further incentives to domestic expansion are provided by new *loss carry-over* rules, increased *expensing* of mineral exploration, and new definitions of *mineral property* and *ordinary treatment processes.*

Under the Defense Production Act a program designed primarily to assist small mining companies has advanced a portion of the costs involved in exploring for domestic minerals. Under this program, administered by the Defense Minerals Exploration Administration in the Dept. of the Interior, approximately $22 million has been spent and more than 750 projects have been undertaken in 30 states.

Government and industry have also made efforts to expand supplies in strategically accessible foreign countries. In 1948 the U. S. depended on the USSR for one third of its chrome and manganese supplies. Shortly thereafter, as part of the *cold war* strategy, these supplies were completely cut off by the USSR. With Government help, largely in the form of underwriting contracts, private industry gave greater attention to other sources of manganese, notably in India, Brazil, and Africa, and other sources of chrome, notably in Turkey, Africa, Cuba, and the Philippines. Today the U. S. need not rely on any shipments of chrome and manganese from the USSR, and stockpile supplies are much larger than at the start of the Korean War. Moreover, domestic production of both manganese and chrome has been encouraged by Government-sponsored procurement programs extending over a number of years.



Covered storage of special concentrates in the national stockpile. Some materials, in this case molybdenum concentrates, are stored in wooden containers. Note the ready access by truck and rail transportation.

Metal pigs in the national stockpile. Note the dry hardstand, aisles separating stacks, clearly marked lot numbers, and provision for handling by fork lifts.

The Trade Agreements Extension Act of 1955, approved June 21, 1955, provides additional authority to assist in maintaining the U. S. mobilization base. This Act provides that whenever the Director of the Office of Defense Mobilization has reason to believe that any article (including, of course, metals and minerals) is being imported into the U. S. in such quantities as to threaten to impair the national security, he shall so advise the President. If the President agrees that there is reason for such belief the President shall cause an immediate investigation to be made to determine the facts. Then, if on the basis of such investigation and the report to him of the findings and recommendations made in connection therewith, the President finds that the article is being imported into the U. S. in such quantities as to threaten to impair the national security, he shall take such action as he deems necessary to adjust the imports of such article to a level that will not threaten to impair the national security.

Much of the expansion under these defense programs will continue in peacetime, and considerable production will be available for domestic use if there are no major defense requirements. To assure expansion of metals and minerals production many Government contracts guaranteed to take specified quantities of materials at certain prices if they could not be sold elsewhere. Thus if there are large industrial requirements for aluminum, copper, and many other materials, it is expected that little will be sold directly to the Government, but rather that expanded supplies will be sold directly to industry.

Current List of Strategic and Critical Materials for Stockpiling

(As of October 1955)

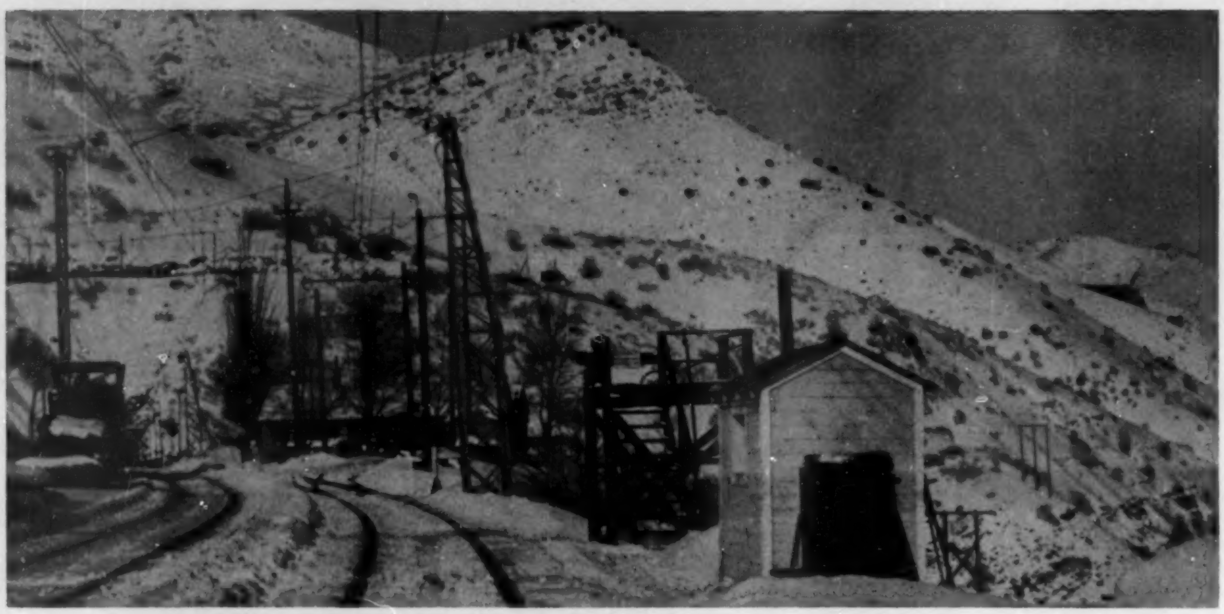
Abrasive, Crude Aluminum Oxide
Agar
Aluminum
Antimony
Asbestos, Amosite
Asbestos, Chrysotile
Asbestos, Crocidolite
Bauxite, Metal Grade
Bauxite, Refractory Grade
Beryl
Bismuth
Cadmium
Castor Oil
Celestite
Chromite, Chemical Grade
Chromite, Metallurgical Grade
Chromite, Refractory Grade
Cobalt
Coconut Oil
Columbite
Copper
Cordage Fibers, Abaca
Cordage Fibers, Sisal
Corundum
Cotton, Extra Long Staple
Diamonds, Industrial
Feathers and Down, Waterfowl
Fluorspar, Acid Grade
Fluorspar, Metallurgical Grade
Graphite, Ceylon, Crystalline and Amorphous
Graphite, Madagascar, Crystalline Flake
Graphite, other than Ceylon and Madagascar—Crystalline
Hyoscine
Iodine
Jewel Bearings, Instrument Jewel except Vee Jewels
Jewel Bearings, Sapphire and Ruby Vee Jewels
Jewel Bearings, Watch and Timekeeping Device Jewels
Lead
Magnesium
Manganese Ore, Battery Grade
Maganese Ore, Chemical Grade
Manganese Ore, Metallurgical Grade
Mercury
Mica, Muscovite Block, Stained and Better
Mica, Muscovite Film, First and Second Qualities
Mica, Muscovite Splittings
Mica, Phlogopite Splittings
Molybdenum
Nickel
Opium
Palm Oil
Platinum Group Metals, Iridium
Platinum Group Metals, Platinum
Pyrethrum
Quartz Crystals
Quinidine
Rare Earths
Rubber, Crude Natural
Sapphire and Ruby
Selenium
Shellac
Silicon Carbide (Crude)
Silk, Raw
Silk Waste and Noils
Sperm Oil
Talc, Steatite, Block
Tantalite
Tin
Titanium Sponge
Tungsten
Vanadium
Vegetable Tannin Extract, Chestnut
Vegetable Tannin Extract, Quebracho
Vegetable Tannin Extract, Wattle
Zinc

Mineral Mobilization Planning

There remains the very important area of mineral mobilization planning, where detailed work is just getting under way.

In view of the fact that the Soviets are now capable of attacking continental U. S. with atomic weapons, far greater attention must be given by Government and industry to problems that would arise following such an attack, problems involving disruption of normal communications, transportation, and power, and loss of labor force through direct injury, dislocation, or the needs of the Armed Services. The Federal Government must be prepared to ascertain promptly the materials position of the U. S. immediately after an attack, including extent of damage to major materials-producing facilities and the critical components needed for repair. Flow of raw materials from mine to consumer must be maintained, and action will be required to maintain materials production if normal sources of electric power are damaged or destroyed.* Broad mobilization plans on a national scale are being developed by the Office of Defense Mobilization, and it is the responsibility of the Dept. of the Interior to work with the metal and mineral producing industries of the U. S. to translate the broad plans prepared by the ODM into definitive and effective mobilization plans for each segment of the mineral industry. The ability of the metal and mineral industry to survive atomic attack and to assist in the defense of the U. S. will depend in large measure on the plans developed and the steps taken *in advance* of war.

*Editor's note: Detailed studies of these problems and many others are presented in *The Domestic Mining Industry in the United States in World War II, A Critical Study of the Economic Mobilization of the Mineral Base of National Power,* by John D. Morgan, Jr., U. S. Government Printing Office, 1940.



Utah Copper Finds Successful And Economical Method for Freezeproofing Waste Dump Cars

by J. C. Landenberger, Jr.

FREEZEPROOFING waste dump cars during winter months has long been of concern at Kennecott's Utah Copper Div. open pit property. Waste mining operations at Bingham Canyon use trains of seven 40-cu yd side-dump railroad cars with electric locomotives to service stripping shovels. Waste is transported an average of nearly 3 miles from the mine benches to dumping areas. During winter months, usually beginning in late October or early November, intermittent and continued periods of freezing together with varying amounts of snow cause waste material to freeze or stick to the sides and bottoms of the cars.

Because of the physical layout of the pit, it is not feasible to freezeproof all waste trains at one or even a limited number of locations. A waste haulage line usually serves one or two mine benches, so that freezeproofing facilities must be maintained at many locations. For example, at the time of writing 27 salting stations were in use.

Past Practice Costly and Inefficient

The previous method had limitations—was costly and inefficient. It employed hot salt solutions prepared at the site of car treatment. Each salting plant consisted of an open-top, 300-gal boiler mounted over a coal furnace. The solution was manufactured by adding rock salt to hot water. The solution was piped by gravity to a spray station or platform adjacent to a track where empty cars were sprayed before their return to the mine bench for loading.

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Adverse problems and effects encountered were:

(a) Solution's inability to prevent sticking.
(b) Feed lines to spray stations freezing or plugging due to temperature and/or precipitate when not in constant use.
(c) Average solution would freeze at about 15°F.
(d) Inefficient use of coal and manpower, and excessive amount of both needed to maintain solution ready for use at any time.
(e) Time required to make new batches, with salting being restricted during such periods.
(f) Corrosiveness of solution and high upkeep costs of plants.
(g) Solution was damaging to clothing.
(h) Hot solution was a hazard to workmen.
(i) The method was least efficient and effective when most needed.

In seeking an improvement it was felt that methods of hot solution or applied heat and their consequent costs should be eliminated if some other satisfactory medium and method could be found.

During the winters of 1950 to 1951 and 1951 to 1952 various types and mixes of oils were tested with some satisfactory results. However, there were some requirements that oil did not satisfy. Oil would not penetrate snow, ice, and thin coatings of muck or waste material, and therefore was effective only if applied to clean cars. It created the additional hazard to workmen, and especially to brakemen, of oil film on car platforms and grab-irons.

Electrical heating of waste cars had received consideration along with other methods such as me-

chanical shaking. These two are mentioned because they would seem obvious considerations. The electrical heating principle was discarded because it would increase potential hazard and mechanical shaking was discarded because it was not practical in present operations.

During the winters of 1952 and 1953 the following were tested: calcium chloride solution, Great Salt Lake water (sodium chloride solution), and magnesium chloride solution.

Calcium Chloride Solution

Calcium chloride is usually purchased in dry, pellet form which simplifies purchase and shipping. Dry $CaCl_2$ was received in tank cars through which the proper amount of water was pumped to manufacture a solution with a freezing point of −37°F, considered adequate for good freezeproofing under local conditions. Distribution of the solution was then made to the various salting locations for testing. At the test locations old boilers and furnaces were replaced with two or three 420-gal tanks and the feed lines to salting or spraying platforms were connected to them. Various spray nozzles were tested to select the proper size and type. The manufactured solution was stored and delivered to salting stations in converted 16,000 to 22,000-gal steam-locomotive tenders. Calcium chloride solution proved a good freezeproofing agent. Its chief disadvantage was a relatively high cost per gallon, principally due to shipping charges from purchase point to Bingham Canyon.

Great Salt Lake Water

The waters of Great Salt Lake are saturated with salt (23 pct approx), and proved to be quite economical in cost per gallon. The lake water was loaded indirectly into the storage and distribution tank cars and transported by rail 15 miles to the mine. Two particular disadvantages were immediately apparent: 1) The solution had a freezing point of −4°F, and in severe weather with sustained cold periods would not be effective; and 2) excessive precipitation of salts due to agitation and moderate temperature changes. It was believed the disadvantage of freezing point could be sustained in view of the cheap cost per gallon by keeping sufficient amounts of calcium or magnesium chloride solution on hand for use during severe or sustained cold periods, but the precipitation of salts resulted in plugged tank bottoms and feed lines.

Cost of Freezeproofing

Material	Cost Per Gal, ¢	Quantity Per Car, Gal	Cost Per Car Sprayed, ¢	Effective Temperature, °F
Hot salt solution	2.07	20.8	43.1	17
G. S. L. water	1.68	1.51	2.5	—4
CaCl solution	10.3	1.25	12.9	—37
MgCl solution	3.5	1.89	6.6	—32

Magnesium Chloride Solution

Magnesium chloride brine was purchased from Bonneville Ltd. at Wendover, Utah, and trucked to the mine. Laboratory tests proved that dilution with water could be made to produce more solution and thereby reduce the cost per gallon, arrive at a point of concentration where no precipitation of salts would occur, and still have a freezing point as low as −32°F. This solution was prepared with 10 parts of magnesium chloride brine to 6 parts of water.

Oil spraying of waste trains is shown above.

The solution appeared to have the best combination of desirable properties of the cold solutions, and was the most effective agent in terms of relative cost. The freezing point, availability, handling and storage properties, and cost per gallon were all attractive. Continued testing throughout the winter of 1953 to 1954, although the season was milder than usual, prompted conversion of the waste car salting facilities to use of magnesium chloride solution. It has been noted that a minor amount of corrosive action takes place with this solution. An effective inhibitor has been developed and is now being tested at Bingham Canyon. Corrosion during the summer of 1954 was effectively relieved in storage tanks by adding a surface film of oil over the solution.

Freezeproofing practice for the winter 1954 to 1955 involved magnesium chloride solution of 10:6 concentration brine with water, throughout the mine. Almost all the salting stations are equipped with at least a capacity of 1680 gal in four 420-gal tanks, and some with 2000-gal where two 1000-gal tanks are used. The tanks at each station are interconnected and supply one spray platform by gravity. Car spraying is accomplished by a hand held spray pipe fitted with three V-jet nozzles producing a single spray the width of a car.

It is of interest to note that testing, experimentation, and use have indicated that an average of 1.89 gal of magnesium chloride solution is needed per car salted as compared with 20.8 gal per car salted by the old method using hot NaCl solution. The basic reason for the extreme difference rests with the ineffectiveness of the weak NaCl solution even though it was hot or warm when sprayed. The table shows indicated costs of solution only per car sprayed as condensed from data acquired during the 1952 to 1953, 1953 to 1954 seasons and part of the winter 1954 to 1955.

Even though it appears that the previous practice of freezeproofing waste dump cars has been supplanted by a dependable medium and method accompanied by substantial cost saving, research will continue to find an even more efficient method.

Design and Operation of Callow-Type Flotation Cells At Kennecott's Hayden Concentrator

by G. P. Sewell

CALLOW-TYPE flotation cells, with various modifications, have been employed at the Hayden concentrator since 1917. Other flotation machines, such as matless-air and mechanically agitated types, which have been tested in competition, have failed to handle tonnages or give metallurgical results equal to the modified Callow-type cells on the Ray ores.

The original type consisted of wide, deep launders with a relatively flat bottom constructed of porous concrete, through which the air was introduced into the flotation pulp. These cells were constructed to handle the tailings from the gravity concentrating process and no special attention was given to preconditioning the pulp ahead of flotation.

History of the Cell Design

During 1917 to 1925 when these cells were in use considerable experimental work was conducted to improve the concrete bottoms as a porous medium. Finally the concrete bottoms were developed to a point where they functioned more effectively. The pulp was substantially neutral, since lime was not used to precondition the pulp, but the mats tended to choke up because of small amounts of dust introduced with the air and also because a certain amount of fine ore pulp was carried into the pores of the concrete by capillary action. This necessitated brushing and chipping the surface of the concrete periodically until it was necessary to renew the porous portion of the cell bottom. As the art of flotation progressed and it became obvious that it could replace the gravity process, a study was made to determine the most efficient type of cell construction before building a new flotation plant to treat the total milling ore.

While experimental work was conducted at Hayden on cell bottoms constructed of porous concrete, the Chino plant in New Mexico had been experimenting with a modified Callow-type cell, using mat bottoms consisting of a special heavy cotton porous medium. Cells were 15 ft long, 30 in. wide, and 24 in. deep at the shallow end, with a bottom slope of ½ in. per ft. Each cell consisted of four mat sections comprising a cast iron pan bottom with a sufficiently wide flange at the top of the pans to accommodate studs for clamping the porous medium in position so as to avoid leakage of air, and recessed on the inner side to accommodate a heavy coarse mesh screen to support the canvas mat. The

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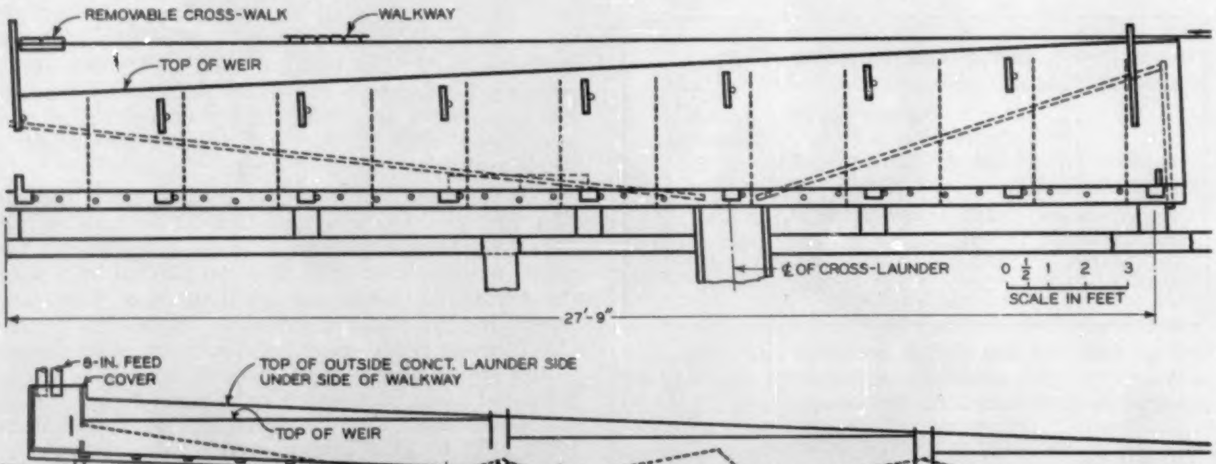


Longitudinal view and section show construction of the Callow-type flotation cells used in the Hayden concentrator. The grouping of these air operated cells is shown in the lower drawing.

Metallurgical Data

Ore	Porphyry schist and diabase
Mineralization	Sulphide copper: chiefly chalcocite and chalcopyrite Nonsulphide copper: various oxides, including silicates, carbonates, cuprite, etc., together with sulphate and metallic copper

Roughing circuit:

Products	Final tailings, rougher concentrate, and scavenger concentrate
Pct solids, original flotation feed	32.0
pH, flotation feed	10 to 11
Time of treatment, min, est.	3
Reagents, average lb per ton	
CaO as milk of lime	4.6
Butyl xanthate	0.075
Amyl xanthate	0.005
Pine oil	0.20*
Pct on 100 mesh, flotation feed (1953)	23.0

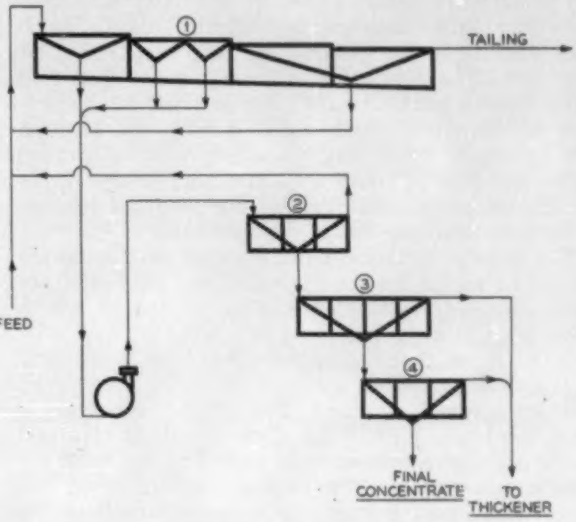
Power distribution:

Flotation dept.	Kwhr per ton ore
Pumps	0.38
Blowers	0.68
Other equipment	0.25
Total	1.31

* No water containing frothing reagents is reclaimed from mill tailings

Assays:

	Cu, Pct	Fe, Pct	Insol, Pct
Flotation heading	1.02	3.4	—
Flotation tailing	0.24	—	—
Rougher concentrate	11.80	20.1	39.7
Final concentrate	22.50	26.0	16.3



Notes:

1) Ten rows primary roughers, four cells in series.
2) Six rows primary cleaners, three 56-in. Fagergren cells in series.
3) Six rows secondary cleaners, four 44-in. Fagergren cells in series.
4) Six rows tertiary cleaners, three 44-in. Fagergren cells in series.

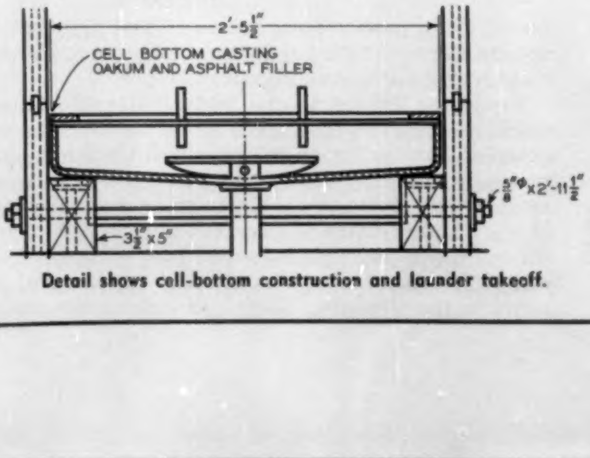
canvas was cut to the full size of the cast iron bottom and punched to fit over the studs. A grid was then placed over the mat and clamped firmly in place by tightening nuts on the studs. The air was introduced into the cast iron pan and distributed to the pulp through the porous canvas mat. After an extensive study of the various cells, it was decided to install the Chino type in the new plant.

A new plant was constructed in 1924 using parallel rows of Callow cells of the Chino modified type. Each row consisted of six 15-ft rougher cells in series, two 15-ft primary cleaner cells in series, and one 15-ft secondary cleaner cell to produce the final concentrate.

The flotation plant was originally designed to handle 500 tpd of ore per row, and tests showed that this was the optimum rate of feed per row during the period that ethyl xanthate was employed as the collecting agent. When higher alcoholic xanthates (amyl and butyl xanthates) were substituted for ethyl xanthate, it was found that the feed rate per row could be increased to 2000 tpd with even better metallurgical results. This improvement reduced the size of the flotation plant to approxi-

Callow-Type Cells

Number of rows	10
Number of cells per row	4
Construction	2-in. Redwood
Number of air pans per cell	8



Detail shows cell-bottom construction and launder takeoff.

Material, air pans	Cast iron
Dimensions, air pans	42x29½x4 in.
Screens used, 3 mesh	0.08 galvanized wire
Principal dimensions of cell:	
Overall length	29 ft 4 in.
Width	30 in.
Depth at head end	24 in.
Depth at discharge weir	38 in.
Froth weir, length	27 ft 10 in.
Number of mats per cell	8
Mat material	42-in. Baker weave air blanket cotton cloth, four-ply
Weight of air blanket cloth	45 oz per sq yd
Porous media per cell	52 sq ft
Porous media per row	208 sq ft
Cell volume	189 cu ft
Average life of mats	58 days
Average original feed per row (1953)	1764 tpd

mately 25 pct of its original size and resulted in a proportional reduction in the amount of air, labor, and maintenance required.

The Present Plant

When the flotation plant was remodeled recently, the changes that had been made and proved in the old plant were incorporated in the new. The Callow-type cells installed are approximately 30 ft long overall, 30 in. wide, 24 in. deep at the shallow end, and 38 in. deep at the discharge weir. Cast iron pans, double compartment type, are laid in the bottom of the trough and supplied with air through 1¼-in. pipes from large headers with a control valve for each cell and an individual control valve for the separate pans. The porous medium consists of mats of four-ply Baker cotton fabric.

The present flotation plant consists of a roughing circuit in which the modified Callow-type cells are used, and a concentrate cleaning circuit in which Fagergren flotation machines of a level type are employed. A rougher concentrate from the upper half of the Callow cells is pumped to 56-in. Fagergren cells for primary cleaning. The rougher concentrate from the lower half of the Callow cells is returned to the primary pump sump in closed circuit with the rougher operation. The cleaner tailings from the 56-in. Fagergren primary cells are returned to the primary sump with the original flotation feed. The tailings from the secondary and tertiary cleaner cells are thickened and the thickened product classified by means of a cyclone and returned to the primary sump after the coarse spigot discharge material of the cyclone is reground.

With the use of lime as a pulp conditioner and the relatively high degree of alkalinity maintained in the flotation circuit, precipitation of lime on the mats shortened their effective operating life. Various methods of preventing deposition of the lime scale were tried, but none was entirely satisfactory. Methods were tried for removing scale when a row was shut down, including application of dilute hydrochloric acid and scraping and brushing the mats by hand. The acid treatment was fairly successful, but the brushing and scraping by hand proved too laborious.

The present method of removing scale consists of brushing the mats of each row at least once a week with a motor-driven wire brush. Rows to be reconditioned are shut down so that necessary mat changes can be made, and the remaining mats are thoroughly brushed and tested before being placed in service at the end of the shift. A rotary brush driven by an Ingersoll-Rand air motor is safe and satisfactory for this purpose. All new mats are soaked with fuel oil before the feed is turned into the row. Fuel oil retards the precipitation of lime within the pores of the mat and adds about five days to the operating life. Two men on day shift are employed to maintain the mats in good operating condition.

Maintaining cell mats in good condition is one of the more important factors for efficient operation of the Callow-type cells. With the mats in good condition, one flotation operator per shift can handle the entire roughing circuit by adjusting the amount of air applied and occasionally removing accumulated sand by means of a *punch stick*. The head flotation operator supervises operation of the rougher plant and the addition of lime to maintain proper alkalinity in the flotation circuit. He also operates the cleaner cells and controls the addition of the frothing and collecting reagents. The reagents used are lime, butyl xanthate, and pine oil.

Roots blowers are used to supply air for the rougher flotation operation at 5.0 psi. Blowers range from 4500 to 11,000 cfm in capacity and are operated individually or in combination to supply the desired amount of air for the rougher flotation operation. Four blowers are available for service.

Work Measurement and Coal Mining

by Theodore M. Barry

WORK measurement is the most common of many titles given to determining the amount of human work required to do any job. A new technique—like most modern management tools—it still needs years of constructive research.

Yet despite known imperfections, it is probably the most enthusiastically used tool of cost control developed in the last hundred years. Over 85 pct of all companies employing more than 100 workers in one of the major industrial areas use work measurement. For a good reason, however, this has *not* been true in the mining industry until very recently. The facts make an interesting story.

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Frederick Taylor, in the mid-nineteenth century, made discoveries that have since led the way to complete revolution in management thinking. Surprisingly (at least, today) he was the first person to realize that it was possible to measure the amount of work a man could be expected to give in exchange for his day's pay. He reasoned that companies had complete control over the amount of material and supplies they bought. They got exact amounts for

exact prices and these could be agreed to before buying. Yet most of their cost was often for labor—and there was no control over the amount of work the labor dollars would bring. (In fact there was evidence of great variations in work output between different employes earning exactly the same rates.)

This led the way to timing a man's work, setting standards, and even paying him for units of *work produced* rather than for the time he spent at work. This was a radical concept, but one which paid great dividends to management people who adapted this time-study or rate-setting system and used incentive pay schemes. Such plans became very popular and companies used to shop for a system as we shop today for an automobile. Men like Bedeaux, Rowan, Halsey, Emerson, and Gantt were famous for their own particular types of compensation plans. Each had a different pay formula, but each used the same basic principle of pay for work rather than for time, and each became world famous.

Recent years have seen the distinguishing characteristics of different systems melt away. Today time study systems are all pretty uniform, incentives are based more and more on one common formula, and the entire field of work measurement is gaining acceptance as a science, rather than a *potpourri* of competing systems.

Its success has been easy to understand. It is simply another tool by which a company can measure what it is buying—in this case, labor. It has paid big dividends because it has helped point to examples of low effectiveness which can be corrected. It has helped greatly to distribute work equally on group-work jobs such as assembly lines. It has proved to be the only fair basis for incentive pay plans. It has pointed the way to great improvements in methods, tooling, and equipment which probably would never have been discovered without the detailed study of each basic part of a job. Companies find that work measurement, in all its phases, has helped improve their labor costs by amounts ranging from 10 pct of their payroll to as much as 30 pct.

Why, then, was the mining industry late in discovering work measurement? The answer to this lies in the basic difference between mining work and the type of work that lent itself to measurement in the early days of this new science. Early standards of work were based on the time an average worker took to do a job if he applied himself conscientiously. This worked nicely for a job such as repeatedly installing and tightening the same size bolt. Since much factory work is largely repetitive and has reasonably constant conditions this kind of a standard of measure was fair and gave a true measure of work performed.

Mining, of course, has no such constant conditions. Early attempts to gain the results of timed standards in mining met with hopeless failure whenever widely varying mining conditions were found. Either the standards proved unfair or were so difficult to set and maintain that the programs were abandoned.

Now all that can be changed. A growing number of coal mining companies are installing programs of work measurement that are working and are producing important cost reductions.

These programs are based on the newest major development in the field of work measurement. It is called *basic time data*. Simply defined, it is a method of setting standards of performance for a job made up of any number of varying component operations by allowing a standard time for each operation, based on the appropriate conditions. Not so simple? Sure it is. It works like this:

1. People in the timestudy or industrial engineering dept. time all the work at a face, for example. They not only *time* the work, and make necessary recordings of what worker effort was observed, and make a record of the proper rest or fatigue allowance justified, but they record the times by elements of *work* and make note of the variables that control these times. For example, in timing a crosscut, the tram from one place to the next would be noted and also the distance trammed. This is followed for each separate element of work in the machine operator's work cycle.

2. This information is recorded in basic time data form, and eventually the company has exact figures for tramming time per hundred feet, for example, under each of several conditions. Or the information is available for cutting across a face in time per foot of face, etc. Each element of work is broken down to either a constant the amount of which is accurately known, or to a variable accurately charted.

3. This data, when completed, can be applied to setting standards for nearly any kind of work encountered in mining. They require more attention and servicing time than factory standards but can be just as accurate. Standards for any crew or worker can be set by simply building up a standard based on the nature of the job as it is currently being done. These basic times, if properly accumulated, can be used to set good standards for poor top, wet bottom, different stope thicknesses, and different timbering structures. The only limit to their applications is work of completely unrepetitive *elements* rather than the old limitation of unrepetitive *cycles*.

This is called a *new* method of work measurement. Actually it has been developed over many years. Perhaps its most challenging trial was in setting standards for maintenance work. This need was a logical result of work measurement progress in manufacturing and process industries. These industries have obtained such value from work measurement in their production work that they wanted to extend the results to the seemingly impossible area of maintenance. Basic time data was the answer. Today a host of companies, large and small, have gained great results from measured standards in maintenance.

What does this mean to mining? Clearly it means a lot. There is nothing repetitive about a maintenance worker's job. He may be repairing a wash basin in the executive suite in the morning and laying a 15-in. pipeline in the afternoon. Yet his work is now being measured, and with substantial results in terms of lower cost.

Mining need no longer feel it is different. Company after company is proving this. Island Creek, Lorado Coal, Peerless Coal & Coke, U. S. Fuels and now hard-rock mines like U. S. Smelting Refining & Mining are among many mining companies joining the production industries in discovering that what Frederick Taylor said nearly 100 years ago is true—*wherever work is performed it can be measured*. And it is expensive *not* to measure it.

Improved Safety and Operating Efficiency With Sound-Powered Phones

by Robert W. Edwards

THE Morris mine, operated by the Inland Steel Co., is located about 5 miles west of Ishpeming, Mich., near the west end of the Marquette Range. The ore, a soft hematite, is mined by sublevel caving and stoping.

A considerable amount of surface water flows down through the cave into the ore or percolates down along footwall dikes in the iron formation. Because of this water, the broken ore cannot be stored in the raises and must be scraped from the sub directly into the tram cars. Efficient tramming, therefore, requires close coordination between the scraping and loading operations. In the past this has been hampered by the lack of a suitable means of communication between the mining contracts and the drawpoints on the tramming levels. Among the devices that have been tried unsuccessfully are flashing lights, air whistles, and electric buzzers.

During World War II the U. S. Navy developed a sound-powered telephone for fire control communication aboard ship. After the war this phone was made available for civilian use and has appeared on the market in various applications—one of them being a toy telephone for children.

A sound-powered phone looks like the hand piece of a regular phone. The phones are interconnected by a two-conductor wire with no power added to the circuit at any point. The system is completely self-contained, portable, and simple to install. There are many variations of this basic design, and one type which looks like a small hand microphone uses a single unit as both transmitter and receiver.

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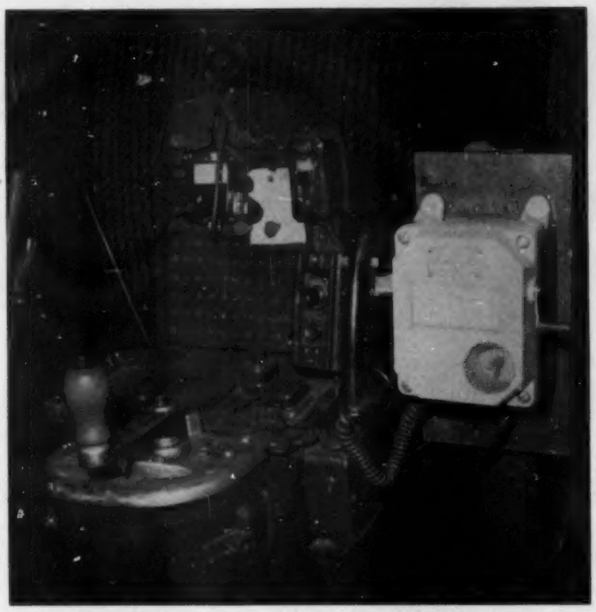
For the first installation Inland used one phone in a mining place and one on the tramming level, connected by a No. 16 Tirex-type cord or shot firing cord. It proved successful except for the lack of a signaling system to call the miner or trammer to the phone. This was solved by installing a flashing light at each phone, operated by a switch at the other end to enable the caller to attract the attention of the person being called. The flashing lights proved better than a sound device because of the high noise level during the drilling cycle.

Since moisture underground would eventually short out the transmitting or receiving units, each phone was placed in a small box heated with a low wattage bulb. However, if one of the units shorts out it is a simple matter to unscrew the headpiece, replace the unit, and send it in for repair. Repair charges are nominal.

This phone setup provides perfect communication between miners and trammers, and results in a smoother, more controlled tramming cycle. The

Checking a phone leading to a mining place from a level.

The sound-powered phone as mounted in the cage.



Phone at the hoist operator's station. Hoistman is given option of hand phone or head set.

miners can tell the trammers when they will have ore to scrape and the trammers can direct the scraping into cars with less spillage.

The next step was to install a third phone on the circuit on the timber sub, giving the miner close contact with the timber hoister. With such communication he can call for his needed supplies easily and without delay. The hazard due to possible misunderstanding while hoisting timber is substantially reduced. Instead of yelling up the raise or pounding on the air pipe, the timber hoister can speak directly to the man at the tugger and control every movement of the cable.

This phone system has proved so satisfactory that every mining place has now been connected to the level and the timber sub by this simple, effective means of communication.

Cage Phones

Another problem was that of providing a reliable means of voice communication from the cage to the hoistman. Before the advent of the sound-powered phone, several wire rope manufacturers had been approached with the idea of a rope that would contain conductors in the core so that a standard battery phone could be used in the cage. Company representatives were told that it was not possible because the wire would break.

The radio cage phone was then investigated as a possible answer to the problem. This first attempt on the Marquette Range met with failure because of wet shaft conditions and inadequate water-proofing of the set. Other operations later overcame this difficulty, and the radio cage phone is now being used successfully at many properties. Work on the radio principle was discontinued because it was felt that a less costly and more satisfactory method could be devised. The hoisting cable with built-in conductors, in combination with the sound-powered phones, seemed to offer an almost failure-proof system with a greater safety advantage.

In cooperation with J. A. Roebling & Sons, a more thorough attempt was made to solve the problem of internal conductors in a mine hoisting cable, and in September 1952 a promising rope design was evolved. An important clue to the solution came from the Army Air Force glider towing cable, which contains electrical conductors and is capable of stretching to almost double its length. The conductors in this cable consisted of flexible, stranded, flat No. 18 equivalent copper wire that was spirally wound around a 1/16-in. stranded nylon core and covered with plastic insulation. One of the conductors was woven into the center of each of the three strands making up the hemp core of the hoisting cable. The three strands were color coded for easy identification. The 1⅜-in., 6x25, preformed hoist cable was then carefully formed on this core. The cost of such a rope is only slightly higher than that of ordinary hoisting rope.

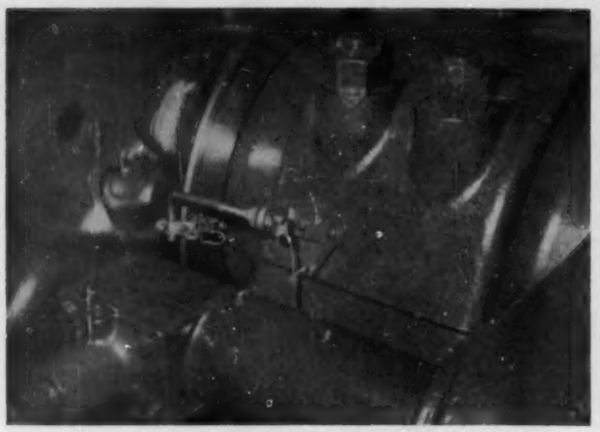
At the cage end of the cable, the steel strands are cut back to expose about 2 ft of core and the cable fastened to the thimble by the regular cable clamps. A small box made of a blanked off 4-in. pipe is clamped to the cable, covering the end of the cable with the exposed core. Here, all three strands are connected to form a single conductor and a waterproof plug is installed. The phone is installed in the cage, with one wire grounded to the cage and the other fastened to the cable through the waterproof plug.

At the other end, in the engine house, the three conductors are similarly combined and connected to a collector ring mounted on the hub of the hoist drum. One wire of the hoist phone is fastened to the insulated brush holder, the other grounded to the hoist frame. A silver graphite brush, rather than carbon, is used so as to minimize circuit noise. The two-wire circuit, using the hoist cable as one conductor, permits successful operation of the system even if two of the conductors in the cable become broken.

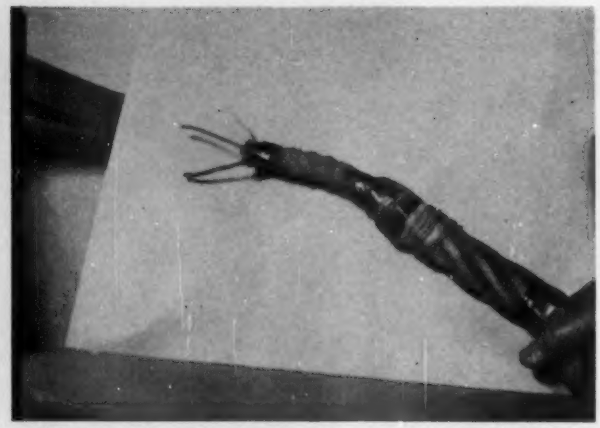
The first cable was installed in March 1953, and to date all three conductors are intact and free from grounds.

This system affords static-free communication from the cage to the hoist, unaffected by power failure. The only maintenance required is to keep the collector ring wiped clean and to protect the phone in the cage from moisture. The cage phone is replaced every day with a dry unit, using two phones

A scraping transfer under wet ore conditions. Because of these conditions, broken ore cannot be stored in raises and must be scraped directly from sub to tram cars. Efficient tramming, therefore, requires good phone communications.



Collecting ring mounted on the hoist drum shaft. One wire is shown from the hoist phone grounded to the frame.



Hoisting cable with strands and hemp center cut back to show the built-in conductors.

alternately, one of which is dried out each day. As in the case of the miners' phones, a means of calling other than yelling or whistling into the mouthpiece had to be developed. This was done by using a waterproof howler system made by the U. S. Instrument Corp. This was connected to the same two conductors with the choice of circuit, ringing or talking, being controlled by a push-to-talk button on the phone. The ringing circuit is supplied by a hand crank generator at either station. This complete unit is changed daily on the cage to eliminate the moisture problem.

The cage phone system is used for communication only and does not replace the normal 110-v cage signal system on the level plat, except for shaft inspection and repair. For this operation an extension phone is used so the inspection crew, standing on top of the cage, can tell the hoistman exactly how much to move the cage, eliminating the possibility of misunderstanding through relayed signals. During this shaft inspection work and during shift changes the hoistman wears a head set similar to a telephone operator's set, so his hands are free to manipulate the hoist controls.

Twice since this system has been in operation there has been power failure while men were being hoisted, and the phones have provided the means of reassuring the men in the cage that they were in no danger.

This system is now being installed on the skips for safe and more reliable communication between the shaft inspector and the hoistman, without the need of an additional man as bell ringer.

Haulage System Phones

Traffic on the main haulage level is controlled by a block signal system. This is effective in prevention of train accidents but provides no means of directing the trammers to different places in accordance with need. Without other means of communication, tramming crews can only work the area within their block system, not knowing when they are needed in a different block until notified by the trammer boss.

In larger mines tramming is directed by a dispatcher having trolley phone communication with each locomotive. However, a small operation does not warrant the cost of such a system to control only four or five trains.

The sound-powered phone again provided the solution. A three-wire grounded circuit was used with two wires for the phones and the grounded circuit for a buzzer system. Heated phone boxes were placed at the shaft dumping point, at all switches and important loading points, and also on the timber sub. Each phone box was equipped with a push button and 250-v dc mine buzzer. A coded call is used, since the buzzer rings at all stations. The common talking feature of this system is sometimes helpful in conference-type conversations between the trammer boss and his crews. This installation has nearly all the advantages of a trolley phone system at a greatly reduced cost.

The haulage system phones, combined with the individual contract phones, now give rapid, positive communication to any point in the mine. Tramming efficiency has improved and supplies are handled with greater efficiency and dispatch. The foreman's overall control is better, and in case of any accident aid can be summoned more quickly. The mine office can get in touch with any man in the mine within 10 min in the event of an emergency message.

Maintenance required is low, consisting principally of replacing and drying out units shorted by moisture. The underground electrician usually carries a few spare units in his pocket for on-the-spot repairs.

Miscellaneous Uses

New uses are constantly being found for the phones. The following examples show a few applications where they have speeded up work and improved the safety of the job.

- During shaft sinking a sound phone on a long portable cable was used to pass up instructions from the bottom to the hoistman and lander. As this setup had no signal system, the shaft hoistman kept the phone on a small stand close to his ear. Again, this did not replace the regular signal system.
- The engineers use sound phones with 250 ft of cable for shaft plumbing, raise work, or other jobs requiring communication.
- Raise miners carry a portable set up the raise for constant and sure contact with the level.
- On the 4½-yd electric shovel, the pit man and shovel operator had trouble coordinating their clutching movements while moving this large shovel. A phone in the cab and at the clutching point eliminated this and may save some squeezed fingers.

More rapid, positive communication by the use of these relatively inexpensive phones has increased the work efficiency and made each job a safer, surer operation.

Better Dropball Connection Cuts Breakage Costs

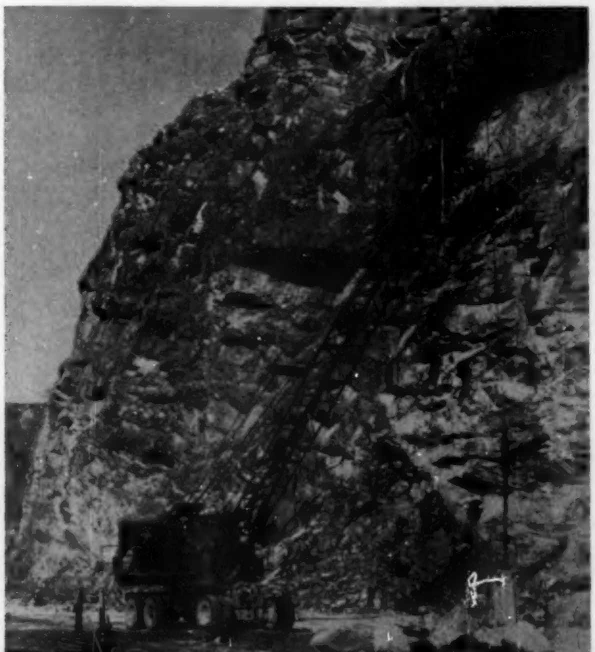
Open pit operators have found the dropball crane a great aid in cutting costs and hazards of secondary breakage. But a common problem in using the unit has been with the shock absorbing connection from the cable to the dropball itself. Blair Limestone Div. of Jones & Laughlin Steel Corp. has come up with a new connector to solve this problem and to save the time usually lost in frequent replacement of the cable slings, chains, or old tires hitherto used at this point.

J&L personnel solved the problem by combining three ideas from other dropball crane owners. Their unit consists of two long U-bolts running through a heavy spring originally made for use on a vibrating screen. Heavy duty swivels attached to the bent ends of the U-bolts provide attachment points for the crane cable and the special chain to the dropball.

Connection at the dropball is by an eyelet welded directly into the mass of steel, and a special alloy chain is connected to this with a clevis.

Gain Several Advantages

The new arrangement has made it possible to save on cable cost by using plastic cord cable, rather than the specially wound wide cable normally specified for dropball work. This is possible because the swivels prevent the cable from twisting as the weight spins.



Dropball at moment of impact, with spring and swivels showing against light background. Crane is Osgood-General 825.

Closeup shows combination of swivels, U-bolts, and spring forming the connection from crane cable to 4-ton dropball.

The equipment used for breakage at the Blair limestone operation consists of an Osgood-General 825 crane with 60-ft boom handling a 4-ton dropball. Mobility permits use for breakage at various points within the quarry. The length of the quarry is 2600 ft and the present floor level is 400 ft wide. Limestone being quarried runs in seams or veins, which favor production of large pieces and aggravates the secondary breakage problem. The combination of dropball and Osgood crane has meant a major saving to J&L; three men with the 825 do a job formerly calling for six men.

Pre-Mixing Antifreeze Saves Time, Dollars for Fleet Owners

Off-the-road equipment operators and other large volume users of antifreeze can lose thousands of dollars each year through inefficient, wasteful methods of cold weather cooling system care. If not enough antifreeze is used, engines can be ruined. Using too much antifreeze is a needless waste of money. The answer to the problem, say Du Pont antifreeze experts, is the use of pre-mixed antifreeze and water solution to service fleet equipment.

Usually, at antifreeze time, whoever is in charge of preventive maintenance, decides what degree of protection equipment should have. Then the amount of antifreeze specified on the protection chart is poured into the radiator. Water is added and the solution is then checked with a hydrometer. This time-consuming operation is repeated from vehicle to vehicle. Additional checks are required throughout the winter.

Equipment operators who have followed the premixing plan agree that it saves time and money and insures against freeze-up damage.

Pre-mixing works like this: The antifreeze is mixed together with water to make a solution that will protect the cooling system to the lowest expected temperatures in the area. Mixing can be done in a separate tank or in standard 54-gal drums.

Once the mixture has been made, a careful reading is made with the hydrometer to make sure the solution provides the desired protection. All that is necessary to make the equipment ready for cold weather is to drain out the cooling systems and refill with the new solution. Drivers and others are then instructed to keep cooling systems filled to the proper level throughout the winter by adding more of the pre-mixed antifreeze solution. Some operators have a drum of the antifreeze and water mixture installed on a service truck which makes the rounds of field operations.

Pre-mixing offers distinct advantages to the equipment user no matter how large or small his operation. Time spent on cooling system care is cut to a minimum, no more antifreeze is used than is absolutely necessary, and engines are properly protected against the cold.

Pneumatic Tire Mounter Scores in the Heavy Truck Field

A pneumatic tire mounter designed by engineers of the Autocar Div. of White Motor Co. proved such a time and labor saver that Autocar has offered to supply plans for the device free to truck users.

Mounting rims for heavy duty trucks takes the time and work of two or three men. With this new pneumatic tire and rim mounting machine one man does the job easily, quickly, safely, and economically. And it is done without the risk of damage to the tire or rim that exists with other methods.

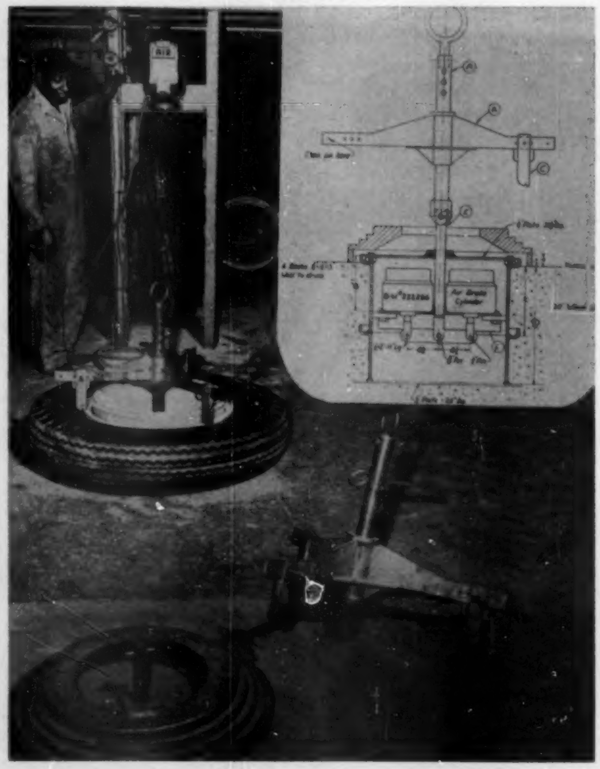
Set over a 24-in. diam pit, 18 in. deep, is a stepped-down, circular casting to hold wheels or demountable rims of 20, 22, or 24 in. diam. The bottom of this casing is at floor level.

Fastened on a plate in the pit below the floor level are a pair of Bendix-Westinghouse 6-in. diam airbrake cylinders with a $2\frac{3}{4}$-in. stroke and a capacity of 1500 to 2000 psi. Both brake cylinder arms are fastened to an 11-in. crosspiece of $1\frac{1}{2}$-in. steel. A 2-in. steel spindle rod attached to the center of this crosspiece rises through the center of the stepped-down casting to about 5 in. above the floor level. A $\frac{5}{8}$-in. cross-rod is mounted through the top of this spindle.

In mounting a tire, the operator first places a rim base on the stepped-down casting. Next, he drops the tire on the rim base, slips the side ring on after and positions the locking ring.

Then he lowers a three-armed spider, hooks it on to the spindle rod that comes up through the center from the pit and locks the two with a quarter turn. The three spider arms notch onto the side ring, and as the operator turns on the compressed air, force it and the bead of the tire down past the locking-ring seat on the rim. With a sharp tap of a hammer, the operator seats the locking ring.

The spider is released and the tire should then be placed in a safety tire stall for inflating.



One man can do a quick, safe tire mounting job with this device. With rim, tire, side ring, and locking ring in position the air valve is thrown, and the spider is forced down. A sharp hammer tap sets the locking ring. Drawing of the device shows at upper right, and copies of the plans may be obtained by writing: Attn.: T. J. Delaney, Autocar Div., The White Motor Co., Exton, Pa.

The Inductive Electromagnetic Method Applied to Iron Exploration

by Stanley H. Ward, Gerald J. Anderson, E. Richard Randolph, and Rolland L. Blake

DURING the last 30 years the inductive electromagnetic method has been used chiefly in the search for massive sulphide mineralization. This application has met with varying degrees of success and in recent years has resulted in discovery of several large orebodies. Little has been written concerning its use in exploration for soft iron ores, but one of the present authors has reported on experiments with massive magnetic deposits.[1]

To augment the exploration tools available to geologists in delineating iron orebodies, Cleveland-Cliffs Iron Co. and McPhar Geophysics Ltd. undertook in 1953 to apply the inductive electromagnetic method to Cleveland-Cliffs properties in the Lake Superior region. As a result of this project, equipment has been developed that enables simultaneous transmission of two audio frequency waves, and the field technique and interpretative procedure involved have furthered exploration in the district significantly.

Thus far, inductive electromagnetic application in the Lake Superior region has been only a development tool, that is, it is used to locate obscured contacts and faults as a part of property expansion and development. However, its application to primary reconnaissance of unexplored areas may be feasible in the future.

The method has assisted in placing drillholes efficiently, and the elimination of excess drilling footages and/or actual elimination of unnecessary holes has amply justified the expense of the geophysical survey.

Cost of the field work involved is comparable on a per station basis to the cost of a magnetometer or superdip survey. Since observations require no reduction, i.e., are directly interpretable, overall expenditure is low, and the scope and detail of the survey can be adjusted in the field as geological-geophysical correlation becomes evident. To a great extent, this eliminates the second-guessing so commonly arising after office calculations are completed on data obtained with other types of geophysical surveys. This unique feature of field interpretation and its associated intimate *feel* of the project area, is, perhaps, one of the most valuable aspects of the inductive electromagnetic method as applied to iron ore exploration.

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Discussion of this paper, TP 4146L, may be sent (2 copies) to AIME before Feb. 29, 1956. Manuscript, Feb. 9, 1955. Chicago Meeting, February 1955.

Basis of Method

Fundamentally, the method involves transmission of an alternating electromagnetic wave, of a chosen audio frequency, which permeates the ground materials in the vicinity of a transmitting, or primary, coil, see Fig. 1. This wave, or field, induces an electric current in any conductor on which it is incident. The flow of an alternating current in a conductor sets up its own, or secondary, radiating electromagnetic field. These two fields form a resultant whose configuration depends on the following characteristics of the subsurface conductors: 1) size, 2) shape, 3) electrical conductivity, 4) magnetic permeability, and 5) frequency of the transmitted wave. To a lesser extent the resultant is also dependent on material adjacent to the conductor, topography, and surface conductivity. For illustrative purposes, the primary, secondary, and resultant fields may be represented by vectors. In operation, the direction of the resultant vector is measured by a small receiving coil tuned to the frequency of the transmitted wave.

Generally speaking, the method can be compared to the transmission and reception of the familiar radio broadcast, with special variations permitting measurement of the effect on reception of intervening materials.

Field Technique

Mechanics of field operation are simple. The mast is set up in a vertical position and is then guyed in place. The transmitting loop then is raised by means of a sheave at the top of the mast and the coil connected to the motor-generator. A special plane table is clamped into position on the mast and the loop is plumbed. The plane table is oriented according to a grid system established over the project area. By means of this plane table it is possible

The Transactions papers appearing in Mining Engineering during 1955 will subsequently appear in AIME Transactions Volume 202 and may be permanently referenced to that volume.

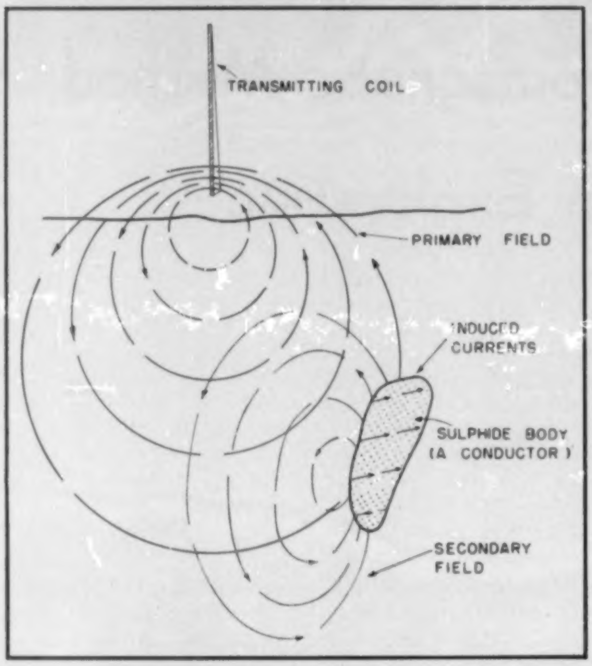

Fig. 1—Fundamentally, the inductive electromagnetic method is the transmission of an alternating electromagnetic wave, of a chosen audio frequency, which permeates the ground materials in the vicinity of a transmitting, or primary coil.

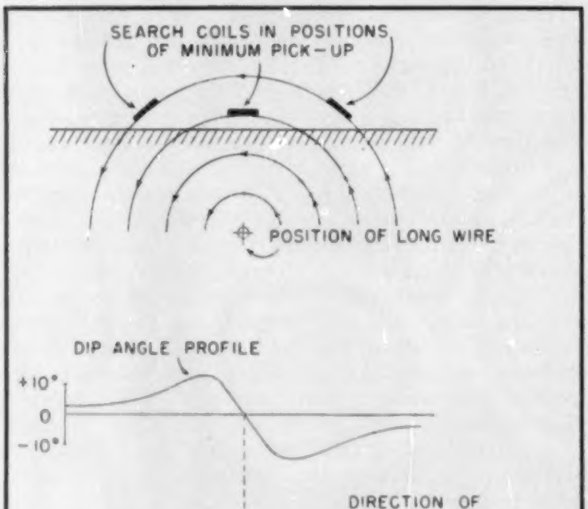

Fig. 2—An illustration of dip angle and a hypothetical dip angle profile.

to orient the loop until its plane is directed towards the position of the receiver.

The receiver operator carries the lightweight receiving coil, the amplifier, and the headset between stations on the traverse lines. A pendulum clinometer mounted on the face of the receiving coil indicates the angle of inclination of the coil to the horizontal. When no conductors are present and the plane of the receiving coil is held horizontally, no signal is heard. If the coil is held in any other position a note is heard. Should a conductor be present, it will be found that the position of zero noise in the earphones is obtained when the coil is at some angle to the horizontal other than zero. This angle of inclination is recorded for each station of observation. Because two frequencies are transmitted simultaneously, the operator selectively receives one and then the other merely by turning a switch.

Fig. 2 illustrates dip angles and a hypothetical dip angle profile. Typical profiles obtained over iron formation are shown in Fig. 3, plotted with their respective traverse lines as the abscissa. The common position of the transmitting coil relative to the traverse lines is also shown.

Some sort of survey control is necessary so that the man operating the transmitter can readily spot the location of the receiver on the plane table to an accuracy of 10 to 20 ft, and so orient the transmitting coil until its plane is directed toward the location of the receiver. Commonly, picketed traverse lines chained from a base line are used for this.

The two-man field party must be coordinated so that at the time of each reading the transmitter operator knows the location of the receiver operator, see Fig. 4. This is accomplished by hand, voice, or radio signals, or a pre-arranged system of time schedules. The most efficient system will depend on particular conditions of each survey. Seldom can the two operators see each other.

The simple design of the apparatus provides low maintenance cost, if reasonable care is used in handling. In a good working day the two-man crew can obtain readings at more than 100 stations. This figure compares favorably with the amount of data obtained from any other geophysical method.

Examples and Interpretations

The inductive electromagnetic method has been applied to iron ore exploration on the Marquette and Menominee ranges in Michigan and on the Mesabi and Vermilion ranges in Minnesota. Although some of this work was brief and all of it experimental, successful application to the hard and soft iron formations can be reported at this time.

Marquette Range, Bijiki Iron Formation: Ores of the Bijiki iron formation are a hard and soft goethite in a horizon about 150 ft thick and dipping 30° to the south, see Fig. 5. The oxidized portion is often contained within unoxidized edges of varying thickness. The ledge outcrop averages 200 ft in width and is uniformly covered with glacial drift about 30 ft deep. The footwall and hangingwall are a nearly similar graphitic, pyritic argillite. The strike of the iron formation at ledge is generally NW-SE, but varies considerably.

Traverses were made across both stripped and virgin sections of iron formation. The transmitter was set up near one edge of the known formation, and traverse lines were run perpendicular to the strike of the formation at 400-ft intervals. Fig. 5

shows a typical curve produced from a traverse over the stripped area.

Under the system of presentation of data shown in Fig. 3, a conductor is indicated at the point where the sign of the dip angles reverses from plus to minus, or where an inflection point in the dip angle profile is interpreted as being significant. Thus on Fig. 5 the dip angle sign reversals, marked with a short solid line, occur over the contacts of the concentratable ore as shown by stripping. Further investigation disclosed sulphides along the footwall contact, and porous, water-saturated material along the hangingwall which may constitute the conductors indicated by the inductive electromagnetic method survey.

There is also a point of inflection (marked with a short dashed line) above the contact between the unoxidized iron formation and the graphitic argillite. The effect of the choice of the transmitter location is very well illustrated in Fig. 5. Note that the 1500-cycle curves do not complete a normal reversal of sign except over the contacts nearest their respective transmitter locations. In general, the closer the transmitter is to a conductor, the stronger the conductor response. Thus when two subparallel conductors are adjacent to one another the one closer to the transmitter, in general, gives the greater response. Hence a conductor several hundred feet to one side of a transmitter situated immediately over an equivalent conductor may cause only an inflection in the dip angle profile along any one traverse line.

Higher frequencies energize lesser conductive bodies than do lower frequencies. Hence the 7000-cycle frequency may energize to an almost equal extent two semiconductive bodies, while the 1500-cycle field may energize appreciably only one of the two bodies. The dual frequency technique in itself indicates which conductors are better or poorer and so aids in the interpretation of geologic factors. In the case of Fig. 5 the 7000-cycle field more completely energized the poorly conductive iron formation and so presents a good reversal of sign on the hangingwall even from the transmitter (A) nearest the opposite contact. The 3500-cycle curve assumes a position intermediate between the 1500 and 7000-cycle curves.

Marquette Range, Negaunee Iron Formation: To illustrate the complexity that may arise in the interpretation of inductive electromagnetic method results under certain conditions, an area of supposedly fairly uniform conditions has been chosen. The iron formation is a magnetic carbonate-silicate in which the economic values depend entirely on the relative concentrating characteristics of the magnetite. The overburden is generally heavy enough to prevent adequate geologic mapping.

Magnetics give only a broad picture of the structures, and because the footwall contains variable amounts of disseminated magnetite, the iron-formation-argillite-graywacke contact is obscured. Although the magnetic carbonate-silicate iron formation is very extensive, certain undefined areas of magnetic oxidized iron formation are known to occur. The inductive electromagnetic method was used in an attempt to 1) locate the footwall contact and 2) define the oxidized areas, which were suspected to be associated with faulting.

Several groups of electromagnetic traverses were made. Secondary lines were run to detail certain conductors. As apparent from Fig. 6, countless major and minor conductors were located. Correlative geologic information is sufficient to identify the oxidized zone from SU 5, the footwall contact and intrusive dikes near SU 1 and SU 2, and two of the major faults. The method has presented a complex pattern of conductors that suggests a complex geological setting in turn opposed to the original premise. An attempt has been made in Fig. 6 to produce a geological interpretation of the area, which in great part satisfies the data.

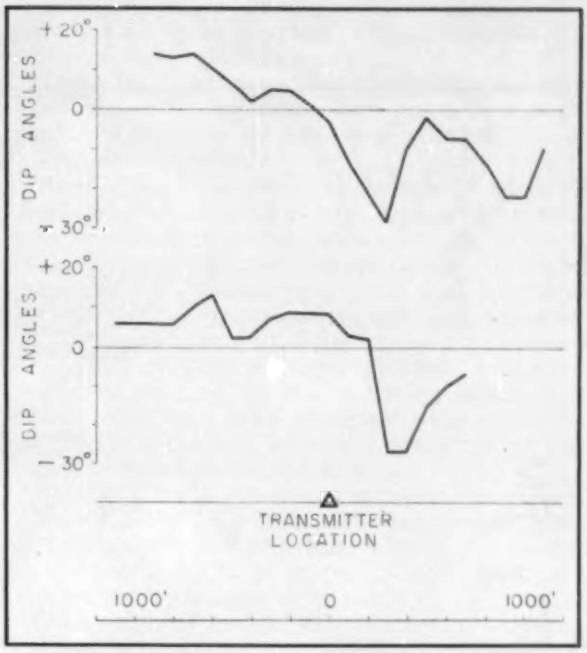

Fig. 3—Typical dip angle profiles obtained over iron formation by the inductive electromagnetic method.

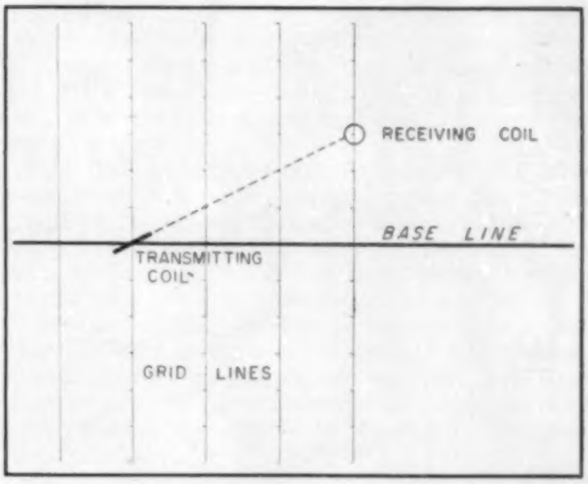

Fig. 4—Sketch showing orientation of transmitting coil for each station of observation.

Thus the method has provided a starting place for structural deductions, but by no means has it given a clear picture of the area. As drilling proceeds, the basic interpretation undoubtedly will be revised, but a logical basis for drilling is available that should reduce the number of holes required to develop the area.

Vermilion Range, Soudan Iron Formation: On the Vermilion Range the inductive electromagnetic

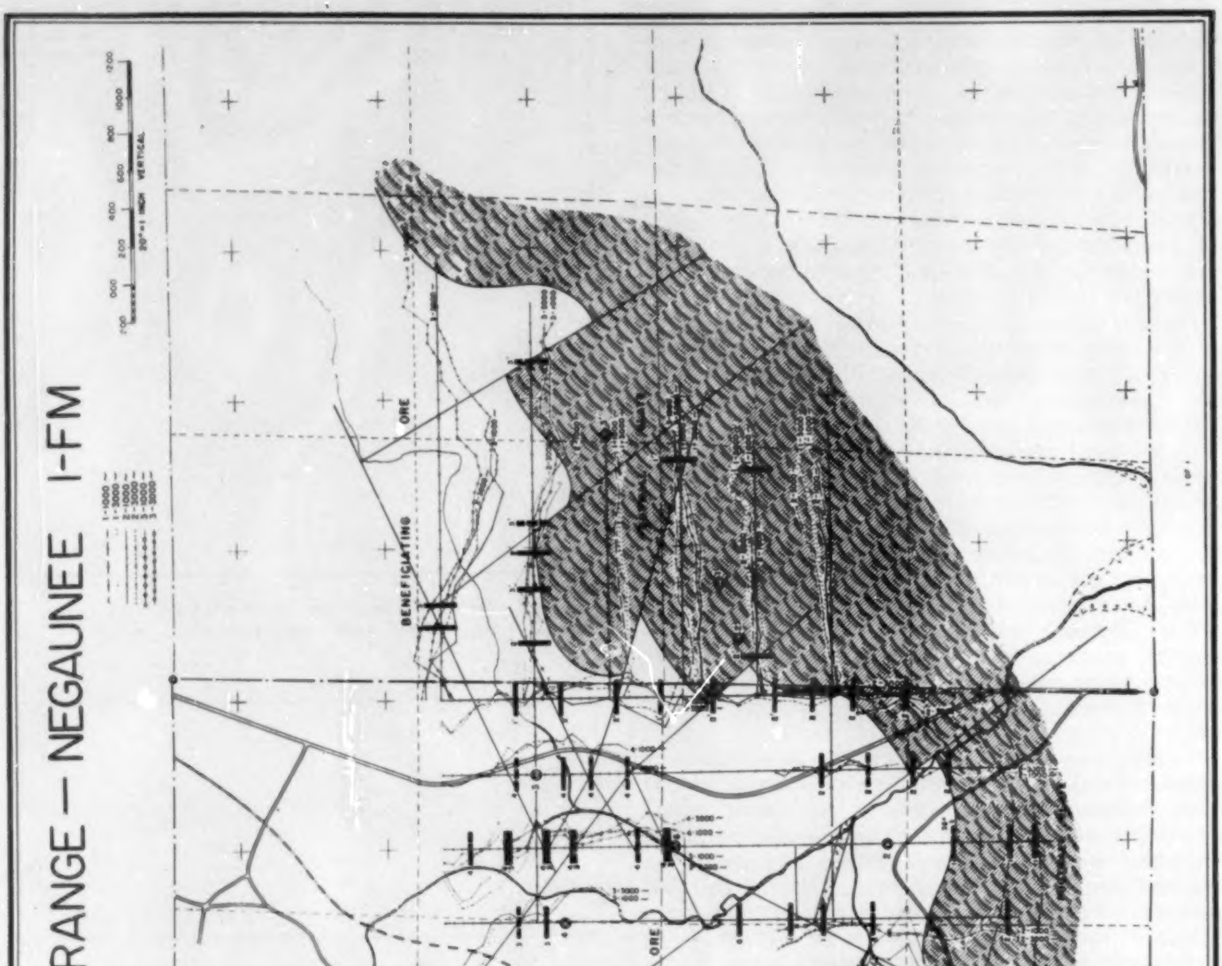

Fig. 6—Electromagnetic profiles from several transmitter positions and a possible structural interpretation.

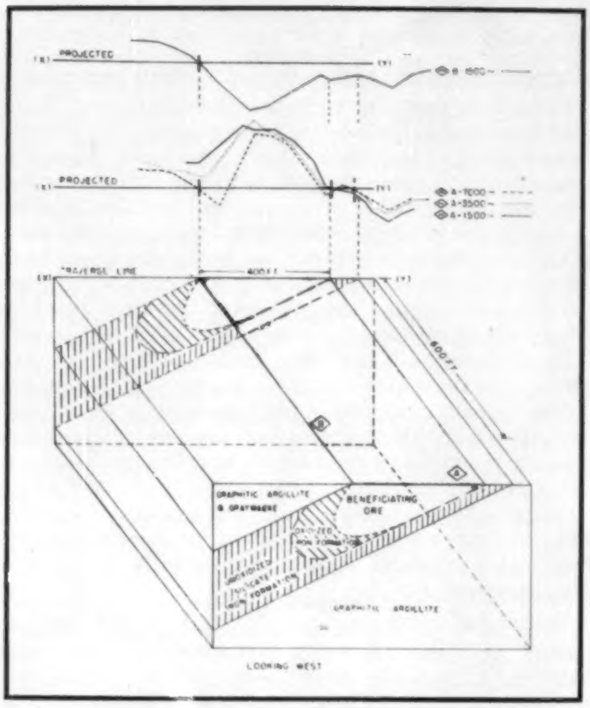

Fig. 5—Marquette Range, Bijiki iron formation. Electromagnetic profiles from two transmitter positions showing relative response from several conductor axes.

method was used to locate contacts of the Soudan iron formation, which is steeply infolded in greenstone. Numerous outcrops facilitate geologic mapping, but some contacts are obscured by glacial drift. Fig. 7 shows a survey on a portion of the Vermilion Range. Here the iron formation varies from magnetic hematitic cherty iron formation to hematitic goethite ore.

Known geologic contacts are shown by a solid line, inferred geologic contacts by a dashed line. Known rock types are shown in darker shading, inferred rock types in lighter shading. Shaded areas represent magnetic highs, and conductors are depicted by short heavy lines or by short dashed lines. Dotted lines show possible geologic contacts as a result of the conductors located.

Two wire fences were encountered in the survey. The fence with the closed loop acted as a strong conductor, whereas the fence with the open loop did not act as a conductor.

Several electromagnetic conductors found in the greenstone far from the contact with iron formation may represent the sulphides common in the greenstone, both as disseminations and as massive lenses.

Several good conductors coincide with the known geologic contact of greenstone and iron formation, and some coincide with inferred contacts. Several conductors suggest the inferred geologic contacts should be changed, as shown by the dotted lines. On the other hand, both strong and weak conductors occur within the iron formation and probably represent bands of conductive minerals.

From Fig. 7 it is apparent that the electromagnetic survey alone did not locate all contacts, but when used in conjunction with known and inferred geologic data, it can help in the interpretation. If a detailed survey is made by setting up the transmitter on conductors at certain known contacts and tracing these conductors to either side, the results should be of further aid in locating drillholes.

Limitations

Although the inductive electromagnetic method results have added to structural information in any map area surveyed in this project, the method is not a complete mapping tool in itself. It has proved of most use where some geologic control is available, and/or where other geophysical data is available for corroboration.

The method becomes difficult to apply and interpret where there are railroads, power lines, telegraph and telephone lines, wire fences, and metallic pipelines, all artificial conductors which obscure the natural ones. Conversely, it can be used to trace buried water lines in other mining problems.

Depth of overburden does not appear to be a serious limitation in the areas worked so far. Because the overburden in these areas was less than 50 ft thick, there was good definition of conductors and interpretation has thus been simplified. However,

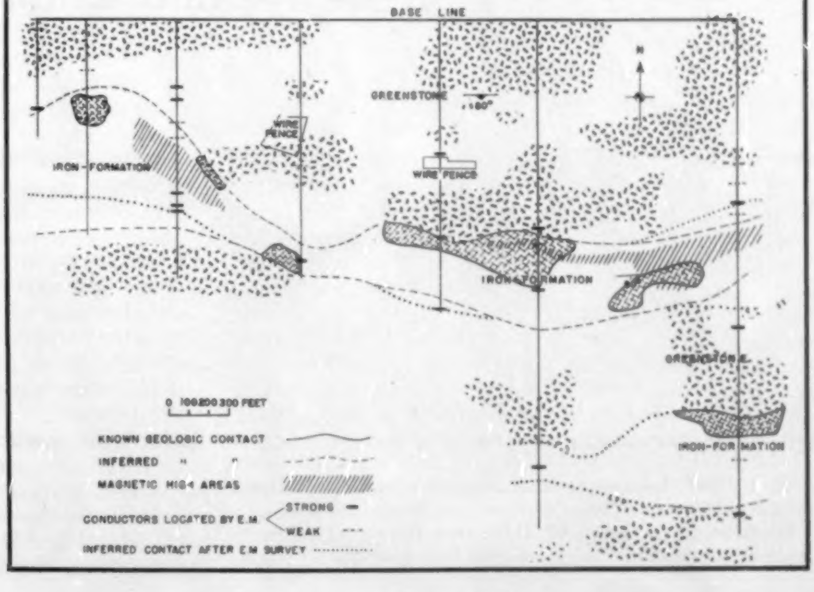

Fig. 7—A portion of the Vermilion Range electromagnetic survey. Although the survey alone did not locate all contacts, when used in conjunction with known and inferred geologic data it was a valuable aid to interpretation.

in one or more areas the overburden has been as deep as 300 ft. Although the inductive electromagnetic method has been of definite assistance in mapping these areas, interpretation is difficult because there is less resolution between adjacent conductors.

Although many conductors parallel the known stratigraphy, others transect it and have generally been attributed to faults. In many cases the actual cause of the conductors is unknown, but thus far it is believed that the following have served as conductors: 1) graphitic or carbonaceous slate and argillite horizons (possibly strike slips); 2) graphitic slips in faults or fractures; 3) massive bands of pyrite and pyrrhotite; 4) massive bands of magnetite; 5) interlocked grains of sulphides and magnetite; 6) highly porous hematite or soft goethite, probably solution-filled (ionic conduction); 7) ionized solution-filled fault zones; and 8) hard blue hematite (very questionable).

From the work completed, it appears that unless one or more of these materials is present as a moderate to excellent conductor in the section no anomaly is likely to result. The anomaly is proportional to the absolute conductivity, and the frequencies employed determine the limits of conductivity which will give a response.

Although the significant contacts are usually indicated, often it is very difficult to determine the actual cause of the inductive electromagnetic anomaly. When the structure is fairly simple, a minimum of surveying is required to trace the iron formation. Where it is complex, a greater number of setups is required to obtain the most complete picture possible. Occasionally ore can be outlined within the iron formation, as has been shown above, see Fig. 5.

Conductors other than those associated with contacts are usually indicated by the data. Often these can be correlated with known geology, but in other cases their cause is unknown. Wet porous horizons within soft iron formation often are suspected as a possible cause.

Summary

This method differs from other geophysical methods in that the result is self-evident, that is, no involved reduction of data is necessary before interpretation can be made. Assuming the geologist is aware of the probable nature of conductors located by the inductive electromagnetic surveys, drilling programs can be planned with greater assurance. Dual frequency work can separate the good from the intermediate conductive bodies and so provide additional information. Because the field work is done efficiently and because direct interpretation in the field actually can save field work, the method compares favorably, on an economic basis, with any other geophysical technique. Several types of materials commonly found in iron ore exploration have been recognized as conductors, and the processes involved in determining and isolating these conductors has been developed with varying degrees of success. The authors consider the inductive electromagnetic method a practical and economical aid in exploring for iron ore.

Acknowledgment

The authors' thanks are extended to the management and staffs of Cleveland-Cliffs Iron Co. and McPhar Geophysics Ltd., for their support and contributions to the project. For their assistance, special recognition must be given to B. H. Boyum, chief geologist; E. L. Derby, Jr., geological consultant; William A. Longacre, geophysical consultant; D. M. Bennett, E. J. Rex, and H. C. Boback, geologists of Cleveland-Cliffs; and William Cartier, William Robinson, Herbert Harvey, George McLaughlin, and Wilfred Sigouin, all of the technical staff of McPhar Geophysics Ltd. and McPhar Engineering Co. of Canada Ltd.

Reference

[1] S. H. Ward: *The Application of Multiple Frequency Exploration to Mining.* Presented at AIME Annual Meeting, Los Angeles, 1953.

Geomechanics — Scientific Tool For the Mining Engineer

by W. A. Vine

WHEN a hole is made in a stressed solid, such as rock pierced by mine openings, equilibrium of the solid is destroyed. To re-establish that equilibrium the stress condition in the rock surrounding the opening becomes rearranged. This rearrangement may or may not develop local stresses in the vicinity of the opening which exceed the elastic strength of the rock. Since stability of the opening depends, therefore, on the strength of the naturally occurring rock surrounding the opening, this rock is an engineering material of construction, and all rock affected by the associated opening or system of openings may be considered a structure. The term *invert* is chosen to describe the formation of the structure —built from the inside, as it were, and a consequence of mining rather than an entity built for a purpose. By definition, an *invert structure* is formed when openings are made underground and is composed of that material on the solid side of a rock-air interface wherein the stress condition is affected by the associated opening or system of openings. The shape of an invert structure is never clearly defined; the *skin* of the structure may be mapped, and even described, but the boundary of the structure within the solid rock mass must be arbitrarily set.

The name *geomechanics* is proposed to describe a branch of scientific knowledge which will encompass principles and working hypotheses for behavior and design of invert structures. It is foreseen that study

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of geomechanics will enable mining engineers to assure stability of invert structures with the same confidence as the engineer who builds a bridge. On the other hand, they may be called upon to use their knowledge to predict or control instability. Consequently, geomechanics has many aspects and covers a wide range. By use of principles developed by this science, shape and arrangement of mine openings and sequence of mining and filling may be placed on a more systematic basis; safe slopes of open pit mines may be engineered; artificial support requirements may be more economically designed; the caving characteristics of a block of ore may be determined from the testing of drill cores; and dimensions and gathering system of the block may be predetermined for most efficient mining.

It is not denied that mining engineers already have developed a rich background of knowledge to guide them in solving practical problems. However, their attempts to take problems to the laboratory have been limited by the complex interrelationship of many variables and by what might be termed *the problem of relative scale*, that is, the enormous masses of material with which they must deal and the great range of structure from crystalline structure to joint systems and regional metamorphism. This has led to what might be called the *art* of mining engineering: the acquisition of intuitive knowledge sufficient to overcome the structural problems of a particular operation. Such intuitive knowledge becomes personal with the individual and defies communication. Also, it limits application of the knowledge to situations where only certain combinations of variables exist, thereby setting up a hazard when knowledge gained at one locality with its particular arrangement of variables is used to solve a problem in an entirely different locality with a different set of variables.

It is the role of geomechanics to reduce the art to a science, or at least to give the art the best scientific basis possible. To do this, it is necessary to recognize the variables that affect the mechanical redistribution of stress patterns when rock masses are disturbed, to separate the variables so that each may be studied in proper perspective, and to develop a nomenclature and a means of communication, so that knowledge gained by this study may be synthesized by practicing engineers into workable tools that will assist them in solving structure problems.

Problems within the scope of geomechanics have been investigated and reported by many persons with various objectives in mind and with various results. Investigations of geomechanic phenomena have been stimulated by disastrous failures of the invert structure. Results of investigating such failures have been made public by Fayol[1] and Rice[1] in their studies of subsidence and by Morrison,[2-4] Spaulding,[5] and others[6] in their studies of rockbursts. The coal industry has contributed much to the understanding of behavior of tabular masses when they become parts of an invert structure. Theoretical studies of the stability of invert structures have been going on for some time in Europe, especially in Germany, France, and Switzerland. More recently the Applied Physics Branch of the U. S. Bureau of Mines has taken up the problem and has made many valuable contributions.[7,8] Among the educational institutions, Columbia University has pioneered in attacking the problem.[9,10] Mining departments of other universities are contributing occasionally,[11-13] to the limit of their under-equipped laboratories and the available manhours that can be devoted to research.

Much material basic to the study of geomechanics can be gleaned from companion fields.

Theory of Elasticity:[14] The theory of elasticity is a formal and scholarly approach to a determination of point stresses and displacements in an elastic solid under certain specified loading conditions. Because treatment of the subject is rigorous, it is necessary to make certain simplifying assumptions before the results are valid. Results obtained by the mathematical technique are limited by the assumptions 1) that the material making up the solid is perfectly elastic, isotropic, and homogenous, and 2) that the stresses applied to the solid are always lower than the yield strength of the material. Another severe limitation is the capability of the average mind to handle the mathematics involved, as the technique applies at present to determining stress conditions around openings of only two specified regular shapes, circular and elliptical.

There are several justifications for including the theory of elasticity as a basis of geomechanics: 1) There must be a start somewhere; as more knowledge is acquired, certain simplifying assumptions may be dropped because the effect of the condition hitherto assumed to be ideal can be handled. 2) Some geologic structures may be of such regular consistency that the assumed condition is not far from the truth. 3) The theory of elasticity gives qualitative results as well as quantitative, that is, it is known from this approach that some parts of the invert structure may be in tension, whereas other parts may be in compression or shear many times the value of the normal stress present before the opening was made.

Photoelasticity:[15-17] Photoelasticity, a laboratory technique that can be applied to small models of certain geologic structures, may be used when the mathematics of the formal approach becomes too cumbersome, for example, when it is desired to investigate stress condition in openings of odd shapes, in pillars of any shape, and in ground surrounding multiple openings. With the exception of added flexibility in the shapes of openings that may be studied, photoelastic studies carry the same simplifying assumptions inherent in perfect substances, isotropism, perfect elastic properties, homogeneity, and relative low stress applications. As the technique is applied to three-dimensional problems, it becomes more difficult to deal with. The great part played by this particular field is in the qualitative determination of the location of concentrated stresses.

Theory of Plasticity: The works of Nadai,[18] Bridgman,[19] and others[20,21] on the flow and fracture of solids at elevated pressures and temperatures and in transelastic deformations extend the subject matter of the theory of elasticity. The theory of plasticity may justifiably be included, therefore, as contributing to geomechanics. Whereas the theory of elasticity does not consider time as a contributing factor in the failure of structures, consideration of plastic deformation carries with it the inherent consideration of the time-rate of movement of one elementary particle with relation to its neighbor.

Many practical mining operations are carried on when parts of the invert structure of the mine bear loads that stress the rock material beyond the elastic limit. (What mining engineer has not experienced *squeezing* or *heavy* ground?) Indeed, when geomechanics is defined to include investigating the means of inducing fragmentation, the mechanics of

flow and failure of rock masses become of major importance.

Soil Mechanics: Drawing from the companion field of civil engineering, geomechanics finds a prolific source of material in soil mechanics,[22] which treats soil as an engineering material of construction with certain physical properties that can be determined experimentally. Based on study of the action of a soil under stress, this treatment leads to increasing accuracy of prediction.

It would be a task to list the direct contributions of soil mechanics to mining engineering. The important contribution of this science is not a formula or technique but the demonstration of a mental attitude. Proponents of soil mechanics know that they are practicing what is essentially an art based upon science and that there is a gap between theory and reality which must be bridged by the practicing engineer through accurate observation, mature judgment, and broad experience. They realize that soil mechanics theory is based upon ideal soils, which differ from real soils in many respects, and that a prohibitive amount of sampling and testing is necessary to reveal all the variables bearing upon a given problem. Consequently they adopt the *observe and learn-as-you-go* method of attack.[22] The working hypotheses and estimates with which a problem is started may then be continually revised and modified as work progresses.

Barodynamics: Bucky and his associates at Columbia University have been working for a number of years on a laboratory technique for centrifugal testing of models[9] which simulates the manner in which stresses are induced on invert structures through the effect of the weight of the entire mass. The technique has contributed materially to understanding the mechanism of failure in tabular masses as might be experienced in sedimentary deposits. Increased understanding of the mechanism of failure in solid bodies composed of consolidated particles rests on the development of better measuring techniques and more refined equipment. Panek,[23] with the Applied Physics Branch, U. S. Bureau of Mines, has recently described an improved centrifuge, from which results may be expected.

Lithology, **petrology**, and allied subjects contribute a knowledge of the physical structure of rocks. These studies concern the material with which geomechanics must deal as they are found in nature and provide the functions of cataloging, classifying, and describing rocks according to physical makeup.

Structural geology contributes knowledge of the origin of pressures and stresses within the earth's crust and the transmission of stress throughout rock masses. It has contributed techniques for correlating orientation of maximum stress by study of fracture patterns in rock.

As the science of geomechanics develops, there will be increased reliance on model studies and geometrical similitude and also on the techniques of engineering statistics to expedite understanding of certain phenomena without its being necessary to separate the many variables of any given problem.

Geomechanics in the Mining Engineering Curriculum

Geomechanics has been in the curriculum of the Missouri School of Mines and Metallurgy for several years, during which time much experimenting has been necessary as to the manner of teaching and the objectives to be sought. During this period it has come to be realized that geomechanics will never be an exact science, but that the degree of exactitude will increase as more and more knowledge is gained and more laboratory techniques are evolved. It must be remembered that mines all over the world are excellent laboratories and that experiments can be carried on continually as the mines are being developed and exploited. The place of geomechanics in the educational institution will be to correlate and assemble information on the problem of controlling, and predicting the inability to control, the action of the invert structure of the mine. Such information may be gathered from mines as well as laboratories and should be passed on to the student with as much of the theory as will be necessary for him to understand the literature as the science develops.

Future of Geomechanics

The time can be visualized when each venture will be guided by a mining engineer versed in geomechanics whose duty will be to anticipate and prevent the violent failure of the invert structure of the mine. His duties should start when the mine is first planned, and his advice should be considered when mining methods are decided upon. As the mine evolves, he will continually test the invert structure with various measuring devices (the geophones, strain gages, and other equipment yet to be developed) so that he may suggest modifying the mining plan, or design the support in particular parts of the mine to alleviate a buildup of high localized stress. His duties will never be complete but will become more complex as the mine goes deeper into regions of greater pressures.

References

[1] Robert Peele: *Mining Engineers' Handbook*, 3rd ed., pp. 10-521. John Wiley & Sons, New York, 1941.

[2] R. G. K. Morrison: The Unsolved Problem of Rockbursts. *Engineering and Mining Journal*, vol. 148, no., 4, pp. 80-82.

[3] R. G. K. Morrison: A General Theory of Rockbursts. *Engineering and Mining Journal*, vols. 148, 149: no. 12 (December 1947, p. 70); no. 1 (January 1948, p. 68); no. 3 (March 1948, p. 66).

[4] R. G. K. Morrison: Report on the Rockburst Situation in Ontario Mines. *Trans.* Canadian Institute of Mining and Metallurgy, 1942, vol. 45, pp. 225-272.

[5] Jack Spalding: Observations on Rockbursts. *Engineering and Mining Journal*, May 1948, vol. 149, no. 5, pp. 91-93.

[6] W. T. Robson: Rockburst Incidence, Research and Control Methods. *Trans.* Canadian Institute of Mining and Metallurgy, 1946, vol. 49, pp. 347-374.

[7] W. I. Duvall: *Stress Analysis Applied to Underground Mining Problems*. Part I, Stress Analysis Applied to Single Openings. U. S. Bureau of Mines *R. I. 4192*, March 1948.

[8] W. I. Duvall: *Stress Analysis Applied tc Underground Mining Problems*. Part II, Stress Analysis Applied to Multiple Openings and Pillars. U. S. Bur. Mines *R. I. 4387*, November 1948.

[9] P. B. Bucky: Use of Models for the Study of Mining Problems. AIME TP 425, 1931. Abstract, *AIME Trans.*, 1931, vol. 96, p. 578.

[10] P. B. Bucky and A. L. Fentress: Application of the Principle of Similitude to the Design of Mine Workings. *AIME Trans.*, 1934, vol. 109, pp. 25-50.

[11] W. R. McCutcheon: The Behavior of Rocks and Rock Masses in Relation to Military Geology. *Colorado School of Mines Quarterly*, January 1949, vol. 44, no. 1, 76 pp.

[12] Bernard York and J. J. Reed: An Analysis of Mine Opening Failure by Means of Models. *AIME Trans.*, 1953, vol. 196, p. 705.

[13] R. G. Wuerker: Measuring the Tensile Strength of Rocks. *AIME Trans.*, 1955, vol. 202, p. 157.

[14] S. Timoshenko and J. N. Goodier: *Theory of Elasticity*, 2nd ed. (Engineering Societies Monograph, 506 pp.) McGraw-Hill Book Co., Inc., New York.

[15] M. M. Frocht: *Photoelasticity*, vols. 1 and 2. John Wiley & Sons, Inc., New York, 1941, 1948.

[16] P. B. Bucky: Stresses in Mine Workings. *Engineering and Mining Journal*, November 1940, vol. 141, no. 11, p. 33.

[17] D. Sinclair and P. B. Bucky: Photoelasticity and Its Application to Mine Pillar and Tunnel Problems. *AIME Trans.*, 1940, vol. 139, p. 224.

[18] A. Nadai: *Theory of Flow and Fracture of Solids*, 2nd ed. (Engineering Societies Monograph, 572 pp.) McGraw-Hill Book Co., Inc., New York, 1950.

[19] P. W. Bridgman: Studies in Large Plastic Flow and Fracture with Special Emphasis on the Effect of Hydrostatic Pressure. McGraw-Hill Book Co., Inc. New York, 1952.

[20] R. Houwink: *Elasticity, Plasticity, and Structure of Matter*, 2nd ed. Harren Press, Washington, D. C., 1953.

[21] D. T. Griggs: Deformation of Rocks under High Confining Pressure. *Journal of Geology*, July-August, 1936, vol. 44, p. 541.

[22] Karl Terzaghi: *Theoretical Soil Mechanics*, 510 pp. John Wiley & Sons, Inc., New York, 1943.

[23] L. A. Panek: *Centrifugal Testing Apparatus for Mine-Structure Stress Analysis*. *U. S. Bureau Mines R. I. 4883*, June 1952.

Ground, Helicopter, and Airborne Geophysical Surveys of Green Pond, N. J.

by W. B. Agocs

IN August 1954 a low altitude test geophysical survey was made in the Green Pond area of Morris County, New Jersey, with a Gulf Research and Development Co. Model II total magnetic field variation magnetometer mounted in a Sikorsky S-55 helicopter. The test was made in this area to compare the results of a high precision, very low altitude magnetometer survey with an existing ground magnetic survey in this area having known magnetite concentrations, so that the method could be used in areas of difficult access for the detailing of airborne magnetometer anomalies of interest in place of ground surveys.

The load capacity of the Sikorsky S-55 permitted installation of a recording scintillation counter so that a radioactivity survey would be made simultaneously with the magnetometer survey.

The area surveyed is located at approximately 41°00'N and 74°28'W, just south and east of the town of Green Pond, N. J.

The outstanding topographic feature of the region is Copperas Mountain, a well defined ridge, maximum elevation 1222 ft, which runs the entire length of the survey. The lowest point in the survey, 810 ft, is in the extreme eastern corner. Topography of the area is shown in Fig. 1.

The three major rock units outcropping in the area are all metamorphic: the Pochuck gneiss, which has been divided into two metamorphic facies; the Byram gneiss; and the Green Pond conglomerate. The relative ages of the Pochuck and Byram formations, both pre-Cambrian, are in doubt, but it is believed that the Pochuck is the older of the two.[1] The Green Pond conglomerate is Silurian.[2] Distribution of the outcrops and mine locations is shown in Fig. 1.

Two facies of the Pochuck gneiss can be distinguished locally—the Copperas Mountain and Kitchell members. The Copperas Mountain member is a hornblende gneiss, and all the mines and prospects in the area are in this unit. The Kitchell is a quartz-plagioclase feldspar gneiss.

The Byram gneiss is a relatively nonresistant valley formation which is high in the potash feldspar.

The Green Pond conglomerate is a well indurated quartzite-conglomerate which forms the Copperas Mountain and the Green Pond Mountain's ridge to the north. It overlies the gneisses with a strong angular discordance that may be a fault.

The geologic structure of the Green Pond area is relatively uncomplicated. The foliation planes of the gneisses dip steeply to the southeast, and the Green Pond conglomerate dips steeply to the northwest. Additional faulting in the area is indicated at the contact between the Kitchell member of the Pochuck and the Byram along the base of the topographic spur extending to the southeast from Copperas Mountain.

The magnetite mines of Pardee, Winter, Davenport, Green Pond, Copperas, and the Bancroft shaft are described by Bayley[1] and Stampe.[2] The ore is in the Copperas Mountain member of the Pochuck gneiss. The magnetite veins are 10 to 50 ft wide and up to 300 ft long, dipping to the southeast at angles ranging from 40° to 75°. The locations of these mines are shown in Fig. 1.

Dip Needle Survey: The dip needle survey shown in Fig. 2 was taken from a U. S. Bureau of Mines Report of Investigations.[3] The figure numbers below the local, individual map area outlines refer to the figures in the aforementioned reports which were not contoured.

The area of the dip needle survey was confined almost exclusively to the outcrops of the Pochuck gneiss. The separation between survey profiles was 100 ft and the distance between stations on the profiles was 25 ft in highly anomalous zones to 100 ft in magnetically flat areas. A total of 16½ miles of traverse was surveyed over an area of approximately ½ sq mile with 2050 stations.

The magnitude of the magnetic anomalies is difficult to determine due to the lack of information concerning the type of dip needle used and the procedure followed in making the dip needle survey. This latter would include the method of "zeroing" the dip needle and the procedure of reading at the stations, whether on the *swing* or statically.

Calibrations made of the Gurley dip needle, Lake Superior type, show a static sensitivity of 385 gamma per degree in the range from −25° to +35°, corresponding to a variation in the total field of −9600 gamma to +13500 gamma in a total field of 57000 gamma, inclination 72°. The sensitivity *increases* to 16 gamma per degree from a deflection of 60° to 76°, and from 76° to 172° the sensitivity decreases continuously to a low of 260 gamma per degree.

From the above it may be seen that it is difficult to assign an arbitrary sensitivity for the dip needle used on this survey. However, an estimated value of 100 gamma per degree may be assigned. On this basis, the majority of the magnetic anomalies, whose deviation is +20°, would be 2000 gamma. Locally, west and northwest of the Pardee mine the magnetic anomaly is +50°, or 5000 gamma; in the Green Pond mine area deviations of +75° are observed that would correspond to anomalies of 7500 gamma.

The areal extent and width of the dip needle magnetic anomalies is comparable to profile and station spacing. Hence it is concluded that part of the detail may be due to control, and the probable cause of the magnetic anomalies is at or near surface exposures of magnetite concentrations in the form of veinlets and disseminations whose locations correspond to the local magnetic anomalies. On the basis of the magnetics, none of the magnetite concentra-

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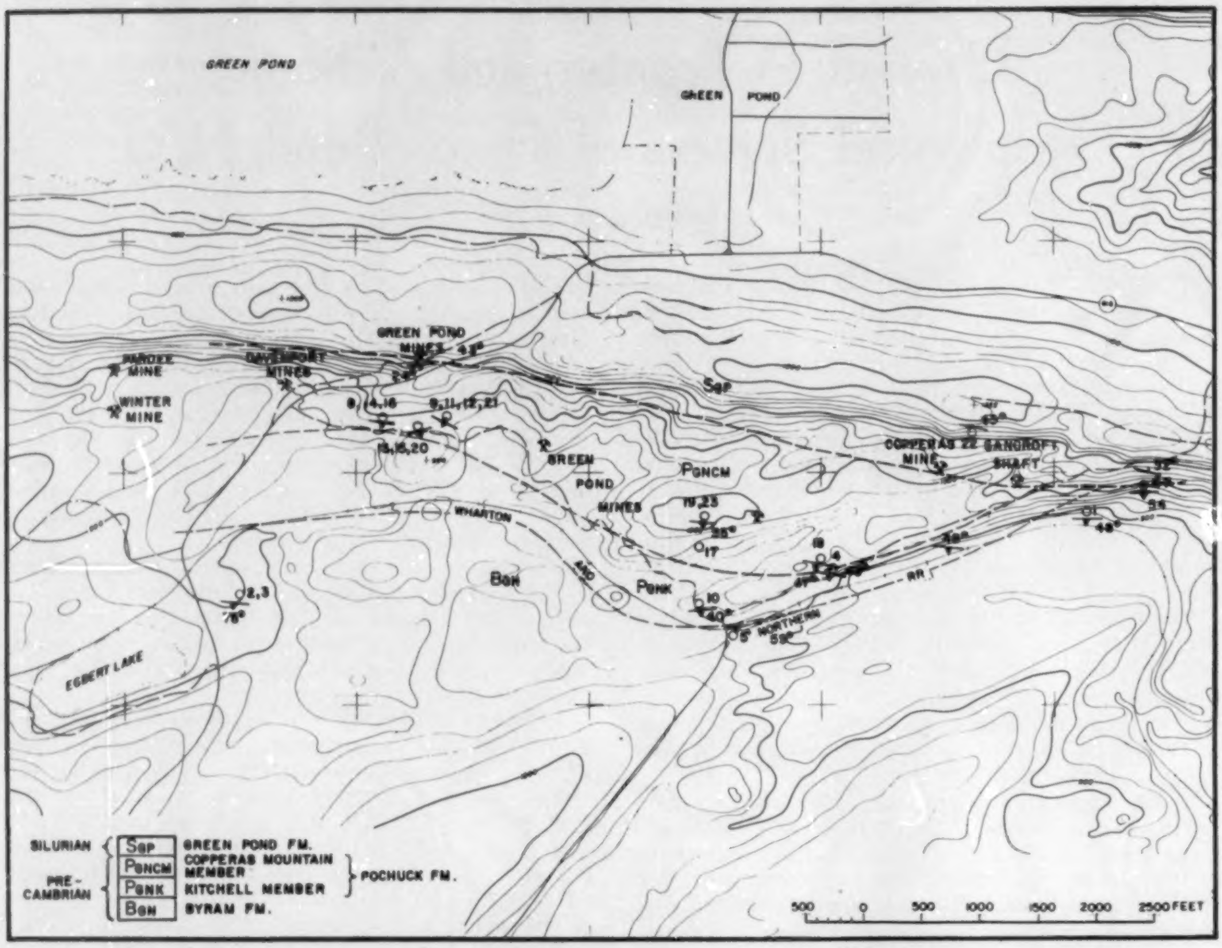


Fig. 1—Topographic and reconnaissance geologic map of Green Pond area, Morris County, N. J., showing contacts, location of mines, and sample locations. Contour interval 20 ft. (Topography taken from U. S. Geological Survey Boonton-Newfoundland quadrangles in New Jersey.)

tions show extensive continuity, but they are local, poddy, low grade concentrations.

The conclusion to be drawn from this survey is that the area contains numerous veinlets and segregations of magnetite, *none* of which would warrant further investigation because available magnetite tonnages are limited and concentrations are spotty.

Airborne Magnetometer Control: Results of the airborne magnetometer survey of the variations of total magnetic intensity are shown in Fig. 3. The magnetic data were obtained on profiles flown northwest-southeast, separated an average distance of ¼ mile and at a mean terrain clearance of 500 ft. Flight paths to guide the pilot were drawn on photo-indices of the area similar to that shown in Fig. 5. The flight path and terrain clearance were monitored with a strip camera and an APN-1 radio altimeter which were tied together and to the magnetic record by means of simultaneously recorded fiducials. These data were related to the ground and to existing planimetric maps by correlation with controlled photo-mosaics as shown in Fig. 4.

The total magnetic intensity map compiled from this survey shows the general trend to be northeast-southwest. The major anomalies are the broad, *regional* negative axis in the northwest, and the three magnetic high closures.

The flexure line between the low axis to the northwest and the high zone to the southwest marks the contact line between the Green Pond conglomerate to the northwest and the Pochuck and Byram gneisses to the southeast. The close agreement between the interpreted and observed contact between the conglomerate and gneiss is due to high angle of contact.

The disposition of the high closures on the general regional trend indicates that the area is anomalous. This is shown by the unique high outlier *A* and the transverse displacement between the two high axes and trends, *B* and *C*. This latter is interpreted as a fault with movement transverse to the high trend. *A* probably lies on a local strike fault, or joint zone, which was subsequently mineralized as indicated by the dual, local, minor gradient changes.

Computation of the distance from the plane of observation to the cause of these positive anomalies shows that it ranges from 500 to 650 ft subflight, or approximately at surface.

The minor reduction in the plunge of the gradient between the second and third lines on the northeast and between the next to last and last line to the southwest, respectively, indicates the location of two other probable high foci which were not resolved due to distance of separation between flight lines, or due to the placement of the control profiles.

Taking the areas of mineralization for the high *A* to be 500x1000 ft, of the central high *B* to be 700x1600 ft, and of the southwestern high *C* to be 800x2000 ft, and assuming a great vertical extent to the mineralization, the values of the magnetic moments per unit volume are calculated to be 0.003 ± 0.001, 0.003 ± 0.0015, and 0.0015 ± 0.001, respectively,

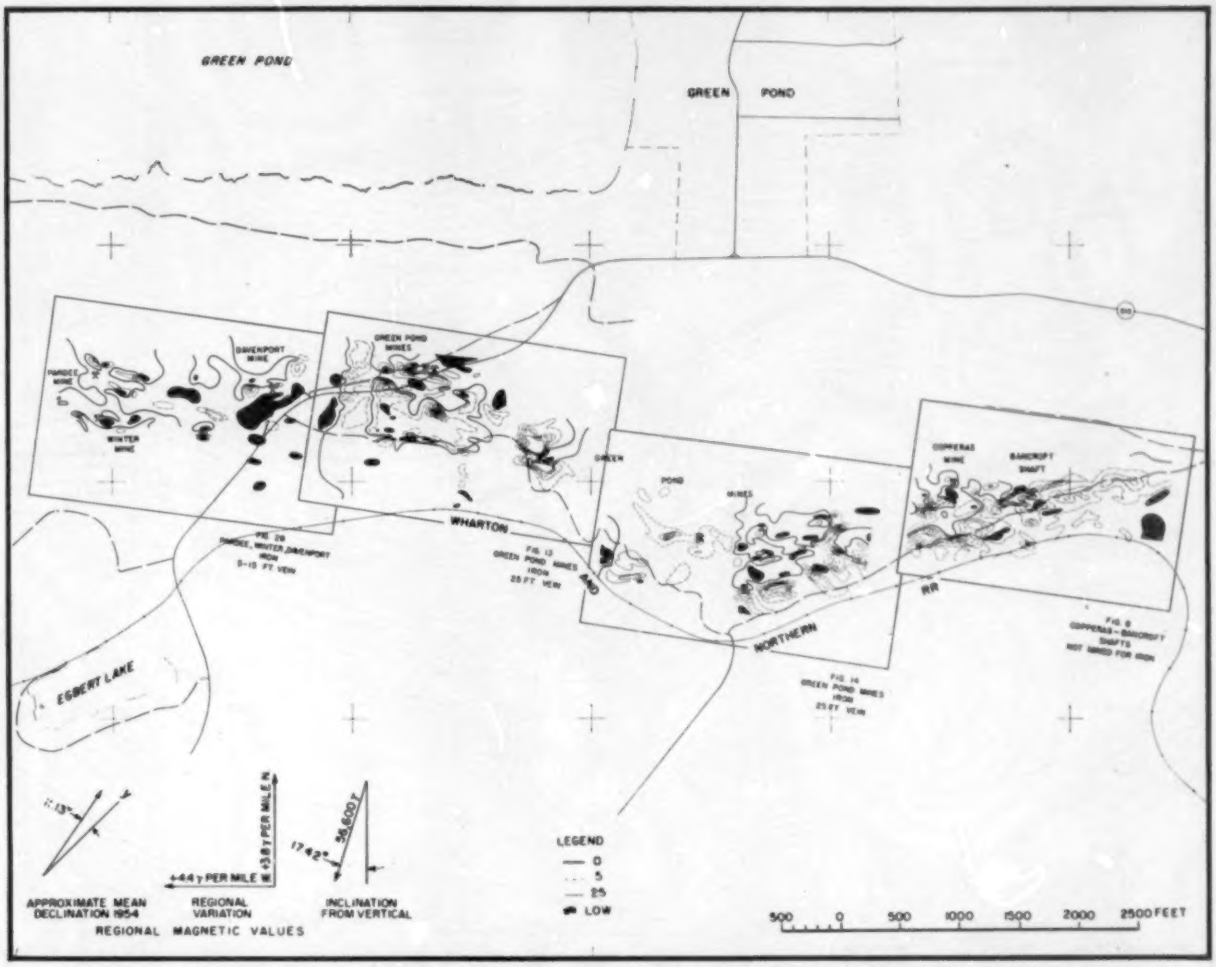


Fig. 2—Dip needle survey based on U. S. Bureau of Mines dip needle observations, 1949.[8] Line direction northwest-southeast. Contour interval 5°. Line interval 100 ft. Figure numbers for individual maps refer to original U. S. Bureau of Mines publications.

for 400, 650, and 400 gamma anomalies. Assuming that the magnetic moment is entirely due to induction, the susceptibilities are of the order of 0.006 cgs, 0.006 cgs, and 0.003 cgs, respectively. The former two values are markedly anomalous, being two to three times the measured value of the gneiss susceptibility, but the latter value approaches the measured value of the rock susceptibility.

Helicopter-Borne Magnetometer Survey: The photomosaic used for the helicopter-borne magnetometer survey is shown in Fig. 5, which indicates the exact location of flight lines along which magnetometer data were obtained. A study of this figure shows that seasonal photographs must be used for these low level surveys in order to tie the locations of flight lines to the ground.

Results of the helicopter-borne magnetometer survey, shown in Fig. 6, may be compared for detail with results of the airborne magnetometer survey in conventional aircraft at 500 ft above terrain shown in Fig. 3 and results of the dip needle survey shown in Fig. 2.

The low level helicopter-borne magnetometer survey presented numerous operational, instrumental, and data reduction problems. Foremost of these was the necessity of developing a wide angle lens for the continuous strip camera which would cover an angle greater than 90° transverse to the flight path, which is photographed with a regular wide angle lens so that the flight path can be tied to the ground. Secondly, the pilot and observer had to observe and tie check points at low levels along the line and at the initiation and termination of the line, so that the flight line spacing would be maintained even with the most difficult ground cover conditions. Thirdly, the terrain clearance had to be maintained at or near tree-top level with minimum clearance variation.

How well the terrain clearance was maintained is shown in Fig. 7. A study of this map shows that *the terrain clearance of the helicopter* varied from 60 to 120 ft, but the sensitive element of the magnetometer was in a towed plastic case or *bird* at the end of a 50-ft cable. Hence, the *bird's* terrain clearance ranged from 20 to 70 ft, but for the most part it was maintained at a clearance of from 40 to 50 ft.

Separation between the flight lines was maintained at an average of 200 ft, even at the extremely low flight level.

Comparison of the low level, total magnetic intensity map of Fig. 6 and the terrain clearance map, Fig. 7, does not show magnetic anomalies whose cause may be terrain clearance variations.

The anomaly *A* from the conventional aircraft, higher level survey has its counterpart on the low level helicopter magnetic record. Whereas the former survey showed an anomaly of 400 gamma, the latter shows an anomaly of 2900 gamma. This field increase in the anomaly of 7½ times, if linear as considered in the original interpretation, would be due to a mass buried at a depth of 30 ft subsurface. Assuming an inverse square increase in anomaly, the depth to the center of mass of the source would be

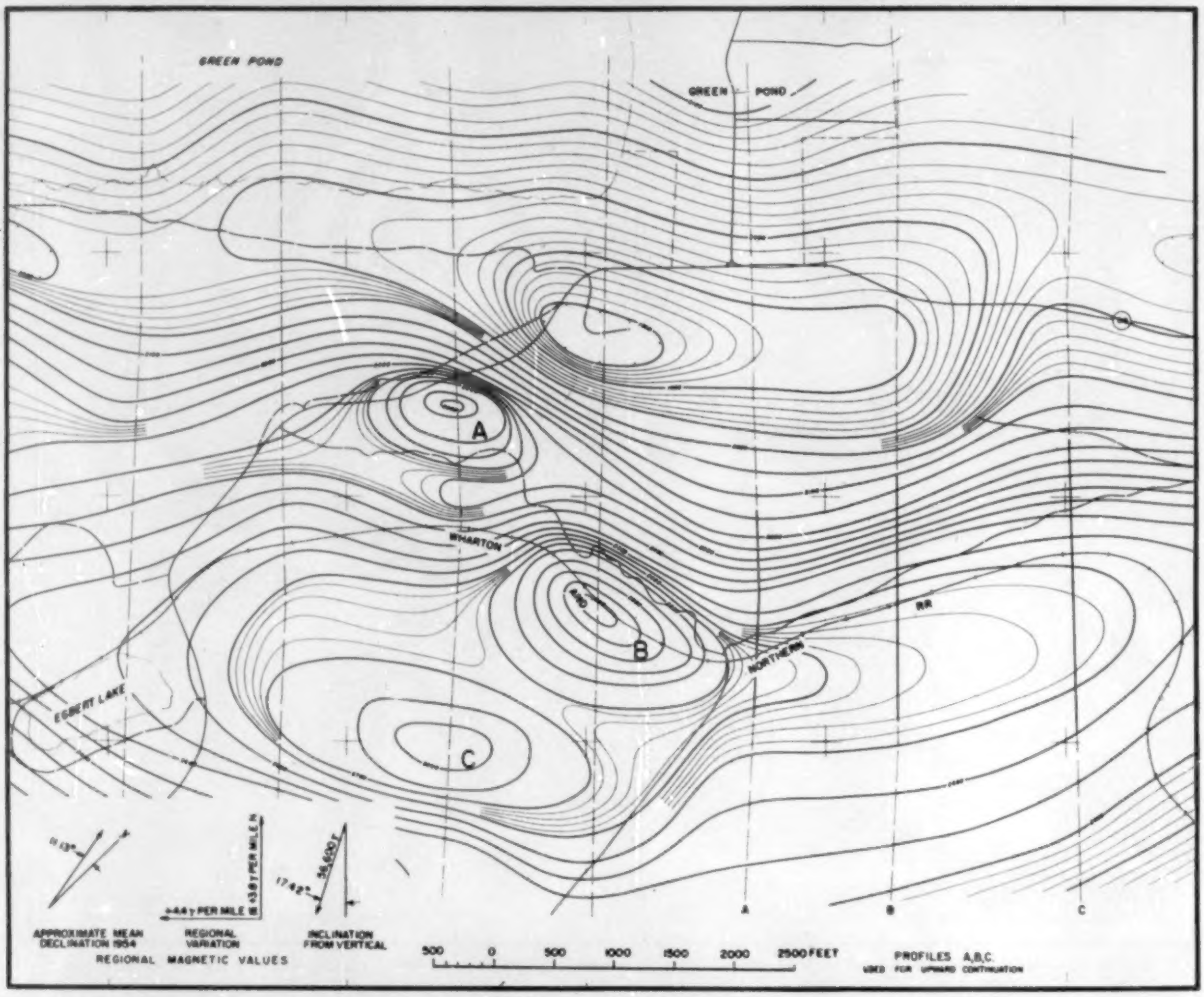
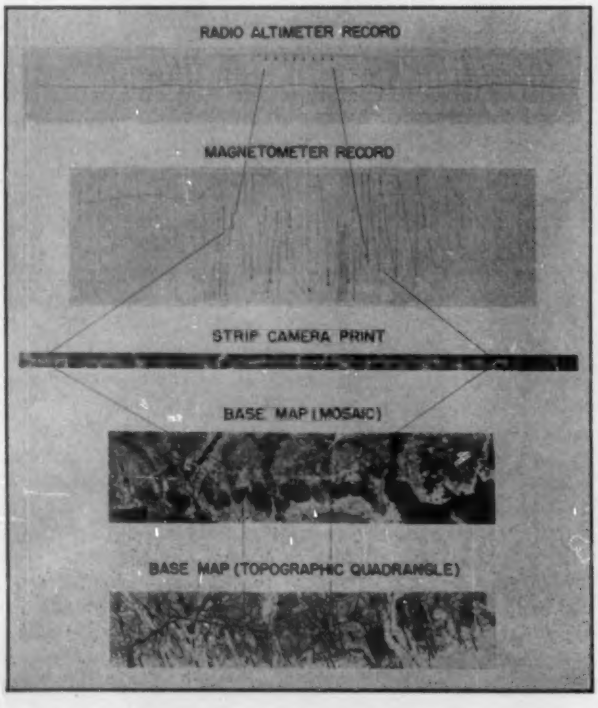


Fig. 3—Airborne magnetometer survey map of the total magnetic field intensity variation showing the flight lines and anomaly locations. Contour interval 10 gamma. Flight interval ¼ mile. Flight direction northwest-southeast. Flight altitude 500 ft. Base intensity arbitrary.



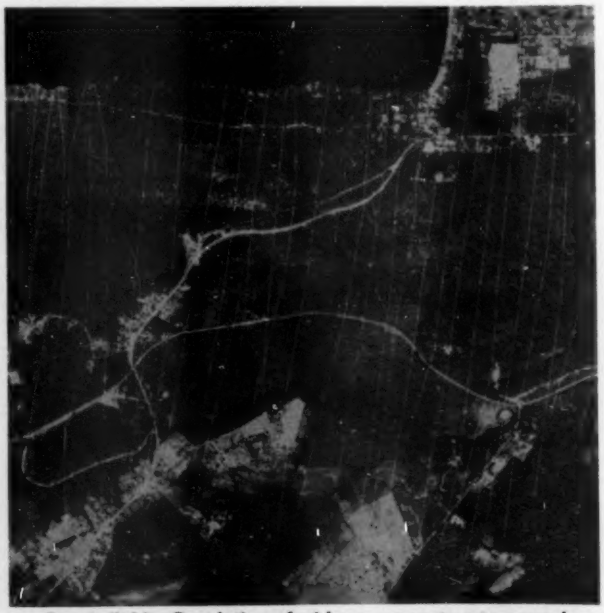


Fig. 4 (left)—Correlation of airborne magnetometer record, 500-ft altitude, with its ground and spatial position. Fig. 5 (above)—Aerial photograph of survey area showing helicopter flight line locations.

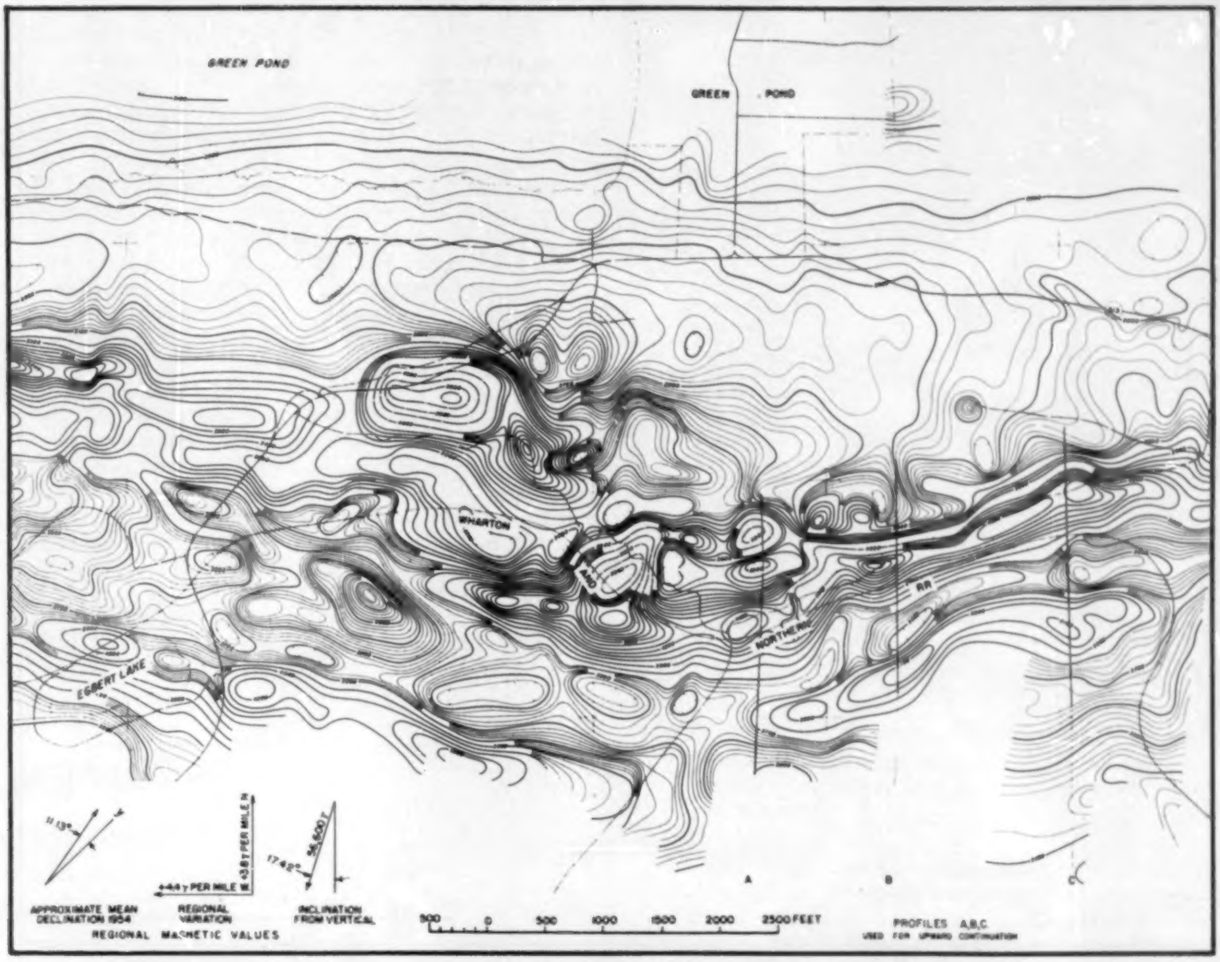


Fig. 6—Helicopter-borne magnetometer survey of total magnetic field intensity variation. Contour interval 20 gamma. Flight interval 200 ft. Flight direction northwest-southeast. Base intensity arbitrary. Average terrain clearance of helicopter 100 ft; of magnetometer, 50 ft.

200 ft subsurface. The former interpretation is believed to be the more nearly correct, the resulting magnetic moment per unit volume is of the same order (0.003) as computed for the airborne feature, and the susceptibility is 0.008 cgs as compared to 0.006 cgs from the airborne survey.

The low level equivalent of anomaly *B* shows a north-south trend. The higher level anomaly has a northeast-southwest trend. This change results from the added detail from the 200-ft spacing used in the helicopter survey as well as the low level of terrain clearance.

The low level survey's magnetic anomaly *B* is 2500 to 2800 gamma as compared to the 650 gamma for the higher level airborne survey. On the basis of the depth determinations, the increase is approximately linear, or the effect due to a dike-like zone of mineralization. The magnetic moment per unit volume of this mass is 0.0045 cgs units, and if the anomalous deviation is due to induction the susceptibility of the material is 0.0079 cgs units.

The low level survey anomaly *C*, when compared with the higher level survey map, shows that this feature is due to summation effects. Hence, no quantitave determinations are made from the low level control.

The northeastward plunge of the higher level survey anomalies *B* and *C* show considerable resolution from the low level control. This higher level feature is found to break into two elongate, high trends separated by a mean distance of 1000 ft in the low level helicopter survey. For this separation of the causes of the anomaly, the higher level should have resolved the individual features. However, for the northern high trend, a local magnetic gradient change is the only indication on the higher level survey map, and the southern high trend is offset from the major airborne axis. The conclusion may be drawn, tentatively, that the low level control has been influenced by the *edge* effects of a mass dipping steeply to the northeast. However, it is difficult to reconcile this deviation on this basis, since the anomaly of the main mass is 600 gamma, and the *edge* effects on the western trend show deviations of from 800 to 1000 gamma.

In order to check the above loss of resolution on increasing the terrain separation from a few tens of feet as in the helicopter survey to 500 ft for the higher level survey, an upward continuation of the helicopter data was made using Peters' method.[4] This was made on lines *A*, *B*, and *C* shown in Fig. 6. These lines correspond to the airborne survey lines as shown in Fig. 3. The results are presented in Fig. 8, which shows the low level helicopter profile and the higher level profile as compared to the resulting upward continuation curve. With the exception of line *A*, an almost complete loss of resolution of the dual positive trend is observed, which is in agreement with the measured results, and the magnitude of the upward continuation anomalies agrees favor-

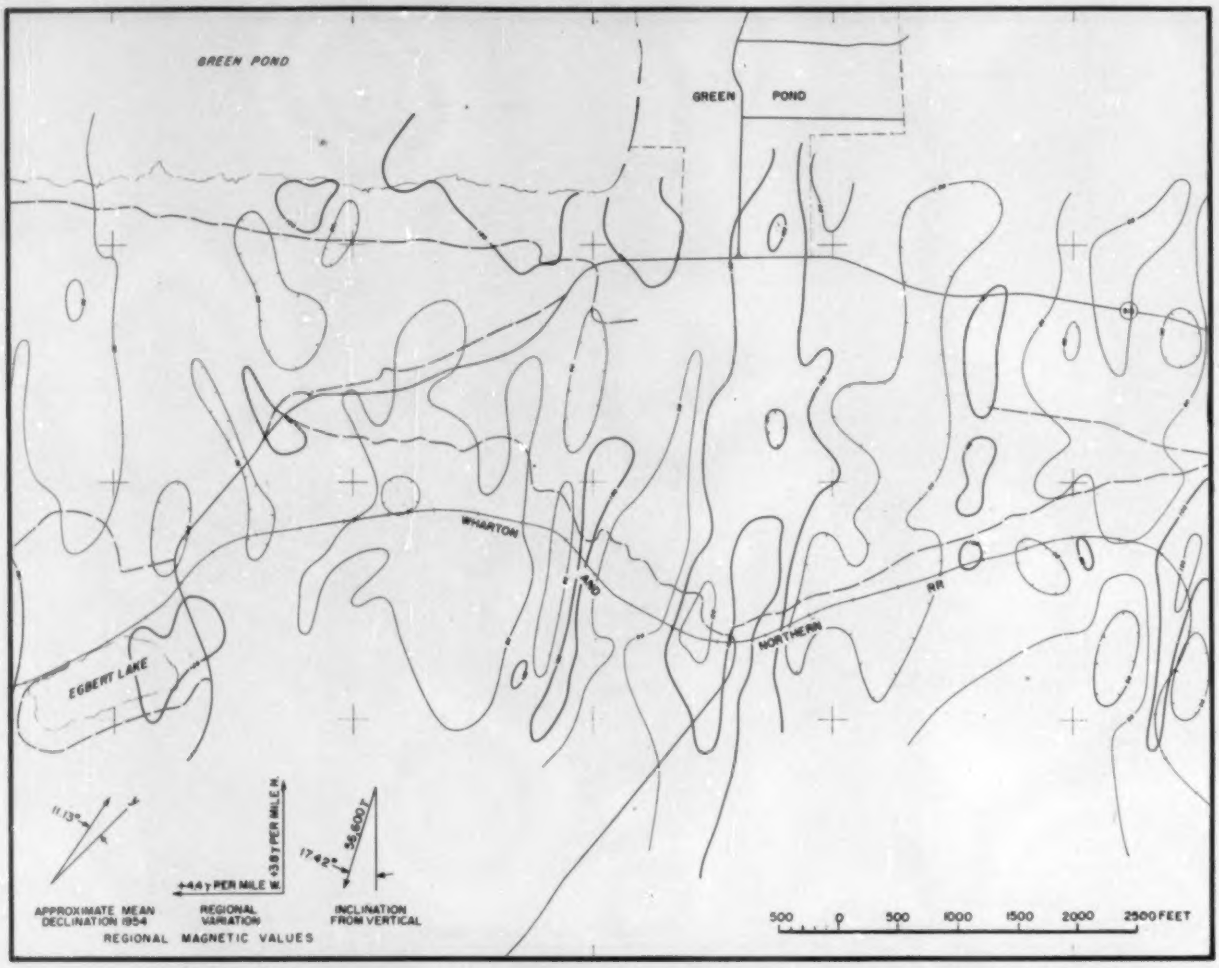


Fig. 7—Map of terrain clearance maintained during helicopter-borne geophysical survey. Contour interval 20 ft. Flight interval 200 ft. Flight direction northwest-southwest. Average terrain clearance of helicopter 100 ft.

ably with the measured higher level airborne magnetometer anomalies.

The location of the Pardee mine is on the plunge of an elongate trend. This mine (?) is located in a zone interpreted to be disseminated magnetite, with attendant local veinlets of magnetite. Under these conditions this feature is not of economic value.

The Davenport mine is located on the northwest flank of a minor magnetic high. The deviation is of low magnitude, and this feature is probably due to disseminated and local veinlets of magnetite.

Table I. Susceptibility Determinations of New Jersey Ore and Rock Samples

Location	Rock Type	Susceptibility x 10^6 Cgs	Density
Washington mine	Magnetite	16518	4.722
Near Oxford, N. J.	Contact gneiss-magnetite (magnetite)	71093	3.718
Near Oxford, N. J.	Same	73269	3.704
Near Oxford, N. J.	Magnetite ore, outcrop	14351	4.835
Near Oxford, N. J.	Gneiss outcrop	100.5	2.611
Green Pond, N. J.			
No. 3	Byram gneiss	2000	2.591
No. 5	Byram gneiss	80.09	2.430
No. 6	Byram gneiss	223.7	2.575
No. 9	Pochuck gneiss	147.0	2.911
No. 12	Pochuck gneiss	59.7	2.904
No. 13		3882.	2.462
No. 15	Pochuck gneiss	143.8	3.067
No. 18	Pochuck gneiss	2157	2.763
No. 20	Pochuck gneiss magnetite	26875	3.252
No. 22	Green Pond conglomerated	29.1	2.461
No. 23	Pochuck gneiss, magnetite	62068	3.509

Anomaly *A*, which is the location of numerous exploration pits of the Green Pond mines, is on the flank of a mass having a susceptibility of 0.008 cgs which would be due to a concentration of 6 pct to 8 pct magnetite by volume. This is too low for commercial development, even though there probably are local zones of enrichment such as the originally mined magnetite vein.

Anomaly *B*, which appears to be of some interest in view of the Green Pond pits on anomaly *A*, is, however, comparable to it, and it is of doubtful commercial interest.

The Copperas mine is located on a minor feature and areally it is of extremely limited extent. The fact is further confirmed on comparison with the dip needle survey in the area of the mine.

The Bancroft mine is located at a contact zone as discussed above. The dip needle survey of a minor zone of mineralization is confirmatory to the low level control.

Susceptibility and Density Determinations: For comparative purposes, and for a knowledge of the magnitude of the susceptibilities of the ores and rocks, susceptibility determinations have been made of a limited number of New Jersey samples. In addition to samples obtained from the Green Pond area, samples obtained from the Washington vein, near Oxford, N. J., and at outcrops near Oxford are listed. Table I gives the results of these measurements made in a susceptibility bridge in a field of 0.6 oersted. The location numbers preceding the rock

type names in the Green Pond area are the same as those shown on Fig. 1.

Assuming in the case of ores that the magnetite has a density of 5.0 and the gangue material a density of 2.5, the Washington mine ore and Oxford ore samples with densities of 4.722 and 4.835 should contain 94 pct and 97 pct magnetite, respectively, whereas the two samples from Oxford with the extreme values of susceptibility and an average density of 3.71 should contain 65 pct magnetite. In the case of samples 20 and 23, the magnetite content should be 45 pct and 58 pct, respectively. It is tentatively concluded that fine grained, disseminated magnetite will have a far higher susceptibility than coarse, massive magnetite.

Comparison of the above values of ore susceptibilities with the computed susceptibilities for the massive causes from the magnetic anomalies shows that they are of little or no economic value, since they are due to low grade magnetite concentrations.

Comparison of Total to Vertical Magnetic Intensity Anomaly: The question may arise as to the comparison of the total to the vertical magnetic field anomaly. In the case of mineral surveys it is particularly important that the location of the maxima with respect to the source of mineralization be known in terms of the depth. To this end the vertical and total field function is presented for the doubly infinite horizontal cylinder.

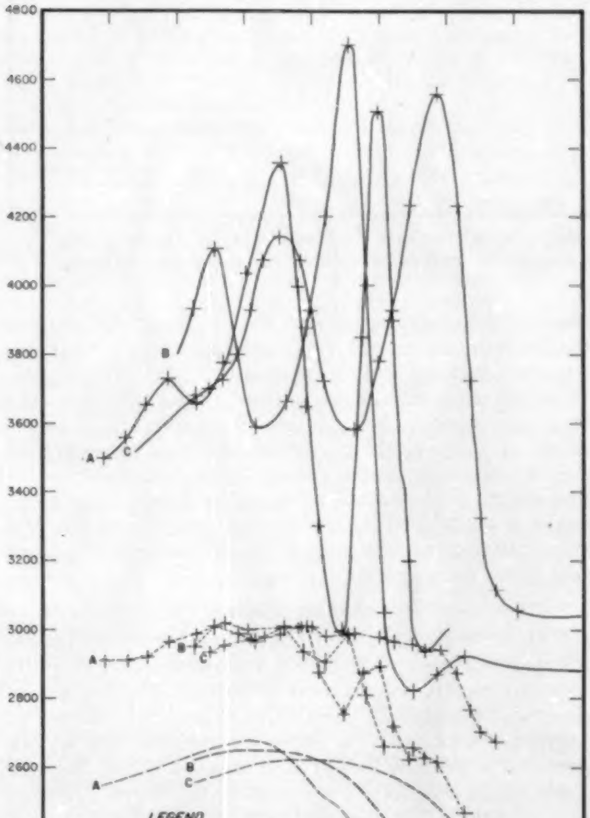


Fig. 8—Comparison between the low-level helicopter-borne magnetometer profile and its upward continuation with the 500-ft level airborne magnetometer profiles on lines A, B, and C.

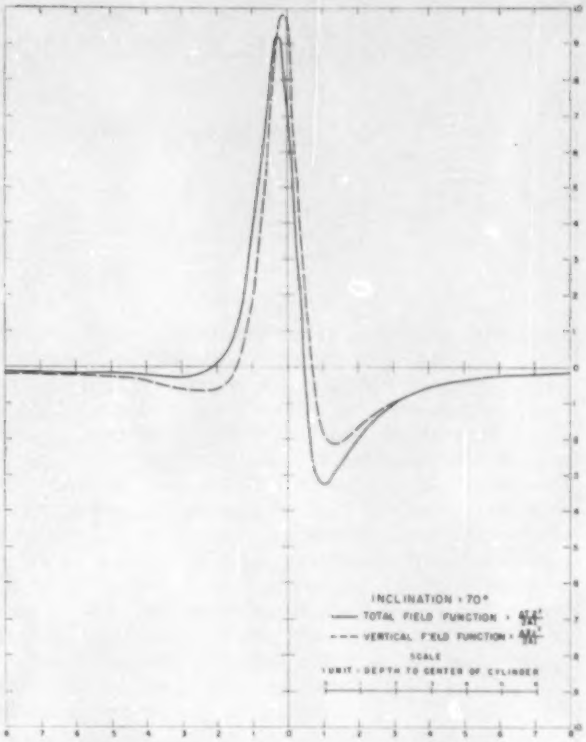


Fig. 9—Total and vertical field function for a cylinder buried at a unit depth, striking east-west. Horizontal distance is in units of depth.

These curves are shown for the cylinder for a magnetic field inclination of 70° in Fig. 9. The maximum of the vertical field is 0.1 n and the maximum of the total field is located 0.25 n south of the center of the cylindrical mass, where $n = x/d$; d is the vertical distance from the plane of observation to the center of the cylinder; and x is the horizontal distance. The ordinates are plotted in units of n, and the abscissa are $(\Delta Z.d^2)/2AI$ and $(\Delta T.d^2)/2AI$, where ΔZ and ΔT are the vertical and total magnetic anomalies, respectively, and d, A, and I are the vertical distance from the plane of observation to the center of mass, A the cross-sectional area, and I the magnetic moment per unit volume.

Radioactivity Survey: The radioactivity survey was made using a Measurement Engineering Laboratory Model AEP-1903-R dual crystal, cosmic ray rejection instrument. The radioactivity data were recorded continuously using a Houston technical instrument dual pen recorder to record the terrain clearance simultaneously with the gamma radiation level. This record was obtained on the low level helicopter survey.

The purpose of this radioactivity survey was to determine the possible correlation between radioactivity and the geologic exposure, and to determine in the course of the survey the effects of topography and the efficiency of correcting the data to a constant terrain clearance level.

The radioactivity data were contoured at a two-scale division interval, which is equal to an 800 count per minute change in radioactivity.

The comparison of the radioactivity map of Fig. 10 with the terrain clearance, Fig. 7, and the topographic map, Fig. 1, shows little if any effect due to these sources.

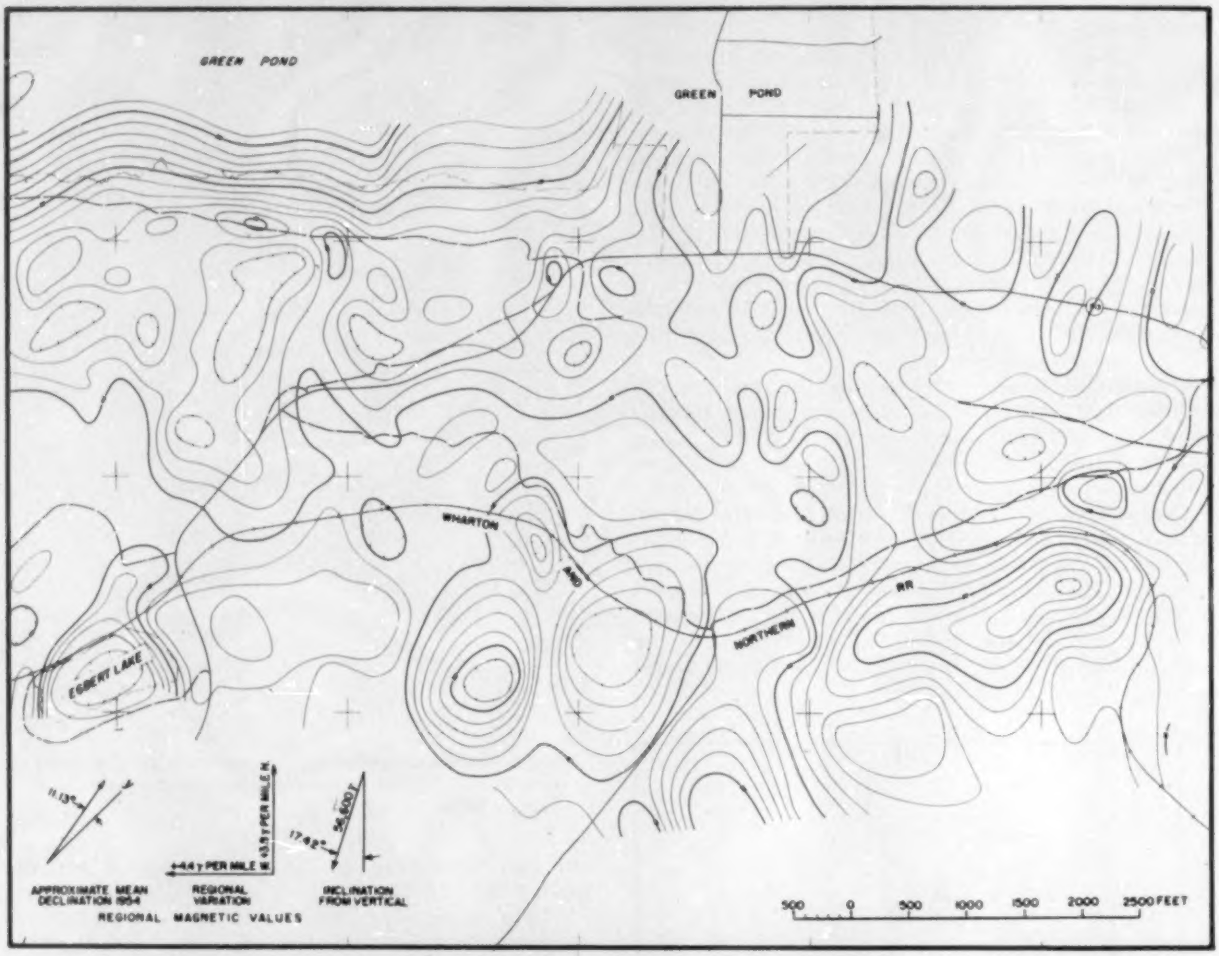


Fig. 10—Radiometric map of the area obtained in the helicopter-borne survey of the Green Pond area. Contour interval 2 scale divisions. Altitude corrected to 70 ft. Flight interval 200 ft. Flight direction northwest-southeast. Average terrain clearance of helicopter 100 ft.

The generally high radioactivity zone, which passes through the center of the area, corresponds to the area of the outcrop of the Pochuck gneiss. This relatively high radioactivity cannot be ascribed to potassium, since the feldspars are mainly sodic and/or calcic. Hence, in view of the definitely anomalous area magnetically it is believed that the mineralization may be post-Archaeozoic or later, with attendant introduction of radioactive minerals.

To the northwest of the aforementioned high zone, the spotty increases and decreases of radioactivity are probably due to the potassium-rich weathering material derived from the orthoclase feldspars in the Green Pond conglomerate.

The abnormally low radioactive zone to the northeast of the Wharton and Northern RR is located over the Byram gneiss outcrops. While the gneiss is relatively rich in orthoclase and hence potassium, the low level of radioactivity is probably due to a quartz detrital cover, except in local zones where the Byram outcrops with little or no cover, or with a predominately clay soil derived from the orthoclase feldspar.

Conclusions

From the study and comparison of the results of the low level helicopter survey with dip needle survey of the Green Pond area it is concluded that the low level magnetic survey results are comparable to, if not superior to, the results obtained from a ground survey. This is because continuous data are obtained; the slight removal from the magnetic sources yields a more nearly true outline of the magnetic sources; terrain clearance may be held within sufficiently close tolerances so that it does not affect the magnetic results; the position of the total field maximum is only slightly displaced from the vertical field's maximum at the higher latitudes; the rapidity and density of control in areas of dense vegetation cover is controlled by the survey needs; and the cost per unit in time and money is comparable to, if not less than, for a ground survey.

Acknowledgments

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References

[1] W. S. Bayley: Iron Mines and Iron Mining in New Jersey—Final Report of State Geologist. *Geological Survey of New Jersey*, 1910, vol. 7.

[2] Geologic Map of New Jersey, USGS, 1932.

[3] J. A. Stampe et al: Magnetic Surveys of Certain Magnetite Deposits in New Jersey, Pt. 2, U. S. Bur. Mines *RI 4432*, 1949.

[4] L. J. Peters: The Direct Approach to Magnetic Interpretation and its Practical Application. *Geophysics*, July 1949, vol. 14, No. 3.

Increasing Coal Flotation-Cell Capacities

A Report on Semicommercial-Scale Experiments

by B. W. Gandrud and H. L. Riley

As far as the present writers know, this system of flotation has not been used elsewhere in this country, but in the last couple of years it has been introduced, with minor variations, at one plant in England and one in Wales.[1] The system has been described and discussed in a number of publications.[2-5] The following is quoted from an abstract of the latest of these,[5] a paper presented at an International Conference on Industrial Combustion in 1952.

> On the basis of experience to date with the commercial plants, it is believed that the kerosene-flotation process incorporates all the necessary elements to make it greatly superior to anything else now available for treating of fines in wet processes of coal preparation. Additional study and investigation are still needed, however, to determine if certain phases of the process can be improved to such an extent as to make it generally satisfactory and acceptable to the industry. Further improvements will be needed with respect to the capacities of the flotation cells and the reagent consumption.

The situation referred to above explains why an investigation is being made of the possibilities of achieving better cell capacities. Results obtained from this investigation, which is still in progress, are believed significant with regard to both cell capacity in general and the relation of cell design to cell capacity in particular. Commercial equipment now being used in a laboratory-type investigation should have performance characteristics similar to those of the larger machines.

Equipment and Procedures: All flotation tests have been made in a standard Denver sub-A 24x24-in. unit cell of 12-cu ft volume. Cell modifications to make it more suitable for the tests were an adjustable front-wall section for varying cell depth and a perforated scraper-drag assembly for removal of the float product. There is also an apron dry-coal feeder, a gravity-feed water supply, reagent feeders, and a centrifugal pump that feeds the mixture of coal, water, and reagents into the flotation cell. A wattmeter connected into the drive-motor circuit records the power requirements of the impeller throughout each run.

Dry coal, water, and reagents are all fed through a pan-type intake to the feed pump. A Sturtevant blower was set up to furnish air for supercharging. A centrifugal pump with a garbage-can intake provides for disposal of refuse flow to an outside settling tank. Figs. 1 and 2 show the flotation cell; Fig. 2 also illustrates the blower for supercharging.

For purposes of this investigation, the percentage by weight of the feed coal recovered in the float product under a standard set of conditions has been considered as the criterion of cell capacity. The authors realize that such a criterion may be somewhat unorthodox, as the term *cell capacity* is usually understood to refer to feed input and ordinarily takes into account the ash analyses of the float product and refuse. However, the word *capacity* is flexible enough so that Webster gives one definition as *maximum output*, a definition which seems to justify, at least partly, acceptance of the above criterion. It has been the authors' experience in the Birmingham district that the ash-reduction efficiency of the coal-flotation process is generally satisfactory and that the only real problem is to increase the rate of float recovery so that the feed rate to any given bank of cells can be increased without undue loss of coal in the refuse.

Originally it was planned to operate the flotation cell to simulate continuous operation during sampling periods. It was assumed that operating for reasonable time with feed coal, water, and reagents turned on would stabilize conditions so that the weight of float coal discharged during a fixed time interval would be an accurate measure of the rate at which the coal was being floated. It developed, however, that this supposition was erroneous. The float coal, caught for fixed time intervals and weighed, gave widely varying results in duplicate runs. Efforts to correct this trouble failed, and it was decided to try to operate on a *batch-test* basis, whereby all the float coal produced during a run on a known weight of feed coal would be caught in tubs, dewatered, and weighed. This method gives consistent and reproducible results, with total float product weight rarely varying by more than 3 or 4 pct on duplicate runs.

The standard test procedure is as follows:

A 132-lb sample of dry feed coal is weighed and placed in the feed hopper. The feeder is adjusted for a rate of 800 lb per hr. Feed water and reagents are turned on, and the feed and refuse pumps are started. One minute later the impeller is started. Six minutes are allowed for the cell to fill up with the water-reagent mixture. The feed of dry coal is started at the end of this 6-min period. One minute later the float-coal removal drag is started.

The float coal is caught in one tub for the first 6 min after the flow of feed coal starts. Tubs are then changed, and the float coal is caught in a second tub until the feed coal runs out, when the tubs are again interchanged to catch the float coal for the remainder of the run in the first tub. The cell is kept running for 3 min with the water and reagents on after the feed stops to allow residual float coal to be removed.

At the end of a test the wet float coal in both tubs is weighed and the total weight recorded. The product in the second tub is used for moisture determination and screen-size analyses. When the

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Discussion of this paper, TP 4072F, may be sent (2 copies) to AIME before Feb. 29, 1956. Manuscript, Dec. 7, 1954. Chicago Meeting, February 1955.

Table I. Comparative Tests of Coal from the Mary Lee Bed, With and Without Baffle Blocks

Product	Screen Size, Mesh	Weight, Pct	Ash,* Pct	Cumulative Weight, Pct	Cumulative Ash,* Pct	Power, Watts
Flotation feed,	−14 +28	40.2	33.3	40.2	33.3	
ROM crushed to	−28 +48	23.5	28.2	63.7	31.4	
14-mesh. Weight	−48 +100	14.3	27.0	78.0	30.6	
132 lb, dry-	−100 +200	9.2	27.5	87.2	30.3	
coal basis.	−200	12.8	32.7	100.0	30.6	
Float coal, with	−14 +28	37.8	9.8	37.8	9.8	With baffle
baffle blocks. Weight	−28 +48	25.8	11.2	63.6	10.4	blocks, impeller
75.9 lb, dry-coal	−48 +100	15.8	12.5	79.4	10.8	required 860 w.
basis. Float-product	−100 +200	9.8	12.3	89.2	11.0	
solids, pct, 49.6.	−200	10.8	12.8	100.0	11.2	
Refuse. Weight by	14 to 0	100.0	56.8	100.0	56.8	
difference, 56.1 lb,						
dry basis.						
Float coal, without	−14 +28	31.6	8.7	31.6	8.7	Without
baffle blocks. Weight	−28 +48	25.6	9.7	57.2	9.1	baffle blocks,
56.8 lb, dry-coal	−48 +100	19.6	10.7	76.8	9.5	impeller
basis. Float-product	−100 +200	11.3	11.2	88.1	9.8	required
solids, pct, 46.4.	−200	11.9	12.2	100.0	10.0	1020 w.
Refuse. Weight by	14 to 0	100.0	46.1	100.0	46.1	
difference 75.2 lb,						
dry basis.						
Flotation feed,	−14 +28	35.9	18.8	35.9	18.8	
14-mesh to 0, screened	−28 +48	23.5	17.2	59.4	18.1	
out of ROM. Weight	−48 +100	16.5	18.1	75.9	18.1	
132 lb, dry-	−100 +200	9.8	18.7	85.7	18.1	
coal basis.	−200	14.3	22.6	100.0	18.8	
Float coal, with	−14 +28	34.9	8.9	34.9	8.9	With baffle
baffle blocks. Weight	−28 +48	26.2	9.8	61.1	9.3	blocks, impeller
99.3 lb, dry-coal	−48 +100	17.7	10.7	78.8	9.6	required 880 w.
basis. Float-product	−100 +200	10.7	10.5	89.5	9.7	
solids, pct, 46.1.	−200	10.5	10.4	100.0	9.8	
Refuse. Weight by	14 to 0	100.0	46.1	100.0	46.1	
difference 32.7 lb,						
dry basis.						
Float coal, without	−14 +28	27.0	7.2	27.0	7.2	Without
baffle blocks. Weight	−28 +48	26.8	8.3	53.8	7.7	baffle blocks,
73.2 lb, dry-coal	−48 +100	21.9	8.8	75.7	8.1	impeller
basis. Float-product	−100 +200	12.5	9.2	88.2	8.2	required
solids, pct, 44.1.	−200	11.8	9.5	100.0	8.4	1040 w.
Refuse. Weight by	14 to 0	100.0	31.7	100.0	31.7	
difference 58.8 lb,						
dry basis.						

* Moisture-free basis.

In the above two sets of tests the increases in weight recovery of float coal due to the presence of the baffle blocks were 33.6 and 35.7 pct, respectively.

total amount of float coal is computed, the percentage of solids thus determined is applied to the material in both tubs.

Experimental Results

A large number of runs have been made to determine the effects of different factors on recovery of float coal. These factors have included ordinary variables of the flotation process itself as well as variables having to do with cell design. Even before the batch-test procedure was adopted, there were indications that baffles in the area surrounding the impeller were beneficial to float coal recovery.

One of the first ideas to be investigated was the use of a set of cement baffle blocks spaced radially around the outside of the impeller diffuser-hood. These blocks are 2x2 in., cross-section, and 4½ in. high. Sixteen blocks are set on end in the bottom of the cell, equidistant on a centerline concentric with and 2 in. beyond the edge of the diffuser hood. They are held together in this position by an inside and an outside band-iron ring. Fig. 3 shows the positioning of the blocks in the cell bottom. Fig. 4 is a view of the blocks outside the cell, with the adjustable front wall section suspended for easy access to the area around the impeller.

Tests with Baffle Blocks: Tables I to IV show results of runs made to determine the effects of the baffle blocks on the recovery of float coal. Throughout these runs all operating variables were kept constant, one test being made with the blocks in place and the other test without the blocks. The reagent combination consisted of 1 part pine oil to 16 parts kerosene, used at the rate of 4 lb per ton of feed. The feed has a solids content of 10.2 pct and the feed rate was 800 lb per hr, dry-coal basis. The only run that deviated in any way from these conditions was the one on Pocahontas coal, shown in Table IV. This run was made on coal left over from a batch obtained originally for use in carbonization experiments. To prevent loss of fines during shipment this coal had been dustproofed with oil. The residual coating of oil from this treatment made the coal floatable enough without further addition of reagents, and no reagents were added in the tests reported in Table IV. Partial screen analyses of the feed and float products are shown in Tables I to IV to give some idea of how the individual sizes are affected by the use of the baffle blocks.

Sampling of the refuse was not considered practical in the standard, batch-test procedure. Obviously, the quality of the refuse discharged from the cell at different times during a run would vary over an extremely wide range, and about the only way to get a representative sample for an entire run would be to recover all the refuse in a settling tank and sample the product as a whole—a procedure that would not be practical with the facilities available. The weights and analyses of the refuse products in Tables I to IV were therefore obtained by differences and by calculations.

Tests with Supercharging: It is often asked whether or not supercharging effectively increases cell capacities. To obtain data that might indicate an answer to this question, runs consisting of parallel tests with and without supercharging were made on

Table II. Comparative Tests of Coal from the Kelly Bed, With and Without Baffle Blocks

Product	Screen Size, Mesh	Weight, Pct	Ash,* Pct	Cumulative		Power, Watts
				Weight, Pct	Ash,* Pct	
Flotation feed.	−14 +28	34.0	5.2	34.0	5.2	
ROM crushed to	−28 +48	25.8	5.3	59.8	5.2	
14 mesh. Weight	−48 +100	17.2	6.2	77.0	5.6	
132 lb, dry-	−100 +200	10.9	7.5	87.9	5.7	
coal basis.	−200	12.1	10.3	100.0	6.3	
Float coal, with	−14 +28	41.1	3.5	41.0	3.5	With baffle
baffle blocks. Weight	−28 +48	25.4	3.5	66.5	3.5	blocks, impeller
90.3 lb, dry-coal	−48 +100	16.1	3.5	82.6	3.5	required 840 w.
basis. Float-product	−100 +200	8.9	3.8	91.5	3.5	
solids, pct, 50.1.	−200	8.5	4.4	100.0	3.6	
Refuse. Weight by differ-	14 to 0	100.0	12.1	100.0	12.1	
ence, 41.7 lb, dry basis.						
Float coal, without	−14 +28	41.8	3.5	41.8	3.5	Without baffle
baffle blocks. Weight	−28 +48	24.7	3.4	66.5	3.5	blocks, impeller
63.6 lb, dry-coal	−48 +100	17.5	3.4	84.0	3.4	required
basis. Float-product	−100 +200	8.4	3.7	92.4	3.5	1000 w.
solids, pct, 49.5.	−200	7.6	4.1	100.0	3.5	
Refuse. Weight by differ-	14 to 0	100.0	8.9	100.0	8.9	
ence, 68.4 lb, dry basis.						

* Moisture-free basis.
In the above set of tests the increase in weight recovery of float coal due to the presence of the baffle blocks was 42.0 pct.

Table III. Comparative Tests of Coal from the America Bed, With and Without Baffle Blocks

Product	Screen Size, Mesh	Weight, Pct	Ash,* Pct	Cumulative		Power, Watts
				Weight, Pct	Ash,* Pct	
Flotation feed.	−14 +28	30.2	34.6	30.2	34.6	
14 mesh to 0 screened	−28 +48	22.6	35.1	52.8	34.8	
out of ROM. Weight	−48 +100	16.3	35.1	69.1	34.9	
132 lb, dry-coal	−100 +200	9.9	34.2	79.0	34.8	
basis.	−200	21.0	42.4	100.0	36.4	
Float coal, with	−14 +28	29.5	6.9	29.5	6.9	With baffle
baffle blocks. Weight	−28 +48	25.4	10.3	54.9	8.5	blocks, impeller
69.5 lb, dry-coal	−48 +100	18.6	14.7	73.5	10.0	required 740 w.
basis. Float-product	−100 +200	11.2	16.5	84.7	10.9	
solids, pct, 45.7.	−200	15.3	15.9	100.0	11.7	
Refuse. Weight by differ-	14 to 0	100.0	63.9	100.0	63.9	
ence, 62.5 lb, dry basis.						
Float coal, without	−14 +28	23.0	6.1	23.0	6.1	Without baffle
baffle blocks. Weight,	−28 +48	25.0	8.8	48.0	7.5	blocks, impeller
60.0 lb, dry-coal	−48 +100	20.6	12.5	68.6	9.0	required 840 w.
basis. Float-product	−100 +200	14.6	14.8	83.2	10.0	
solids, pct, 42.7.	−200	16.8	14.9	100.0	10.8	
Refuse. Weight by differ-	14 to 0	100.0	57.8	100.0	57.8	
ence, 72.0 lb, dry basis.						

* Moisture-free basis.
In the above set of tests the increase in weight recovery of float coal due to the presence of the baffle blocks was 15.8 pct.

Table IV. Comparative Tests of Pocahontas Coal, With and Without Baffle Blocks

Product	Screen Size, Mesh	Weight, Pct	Ash,* Pct	Cumulative		Power, Watts
				Weight, Pct	Ash,* Pct	
Flotation feed. Washed	−14 +28	42.5	6.2	42.5	6.2	
⅜-in. to 0 crushed	−28 +48	25.8	5.7	68.3	6.0	
to 14 mesh. Weight	−48 +100	13.6	6.0	81.9	6.0	
132 lb, dry-coal	−100 +200	7.9	6.0	89.8	6.0	
basis.	−200	10.2	6.8	100.0	6.1	
Float coal, with	−14 +28	35.3	4.0	35.3	4.0	With baffle
baffle blocks. Weight	−28 +48	28.7	4.0	64.0	4.0	blocks, impeller
104.8 lb, dry-coal	−48 +100	17.1	4.0	81.1	4.0	required 880 w.
basis. Float-product	−100 +200	9.5	4.2	90.6	4.0	
solids, pct, 48.0	−200	9.4	4.3	100.0	4.0	
Refuse. Weight by dif-	14 to 0	100.0	14.2	100.0	14.2	
ference 27.2 lb, dry basis.						
Float coal, without	−14 +28	30.1	3.1	30.1	3.1	Without baffle
baffle blocks. Weight	−28 +48	27.8	3.4	57.9	3.3	blocks, impeller
69.3 lb, dry-coal	−48 +100	19.3	3.5	77.2	3.3	required 1070 w.
basis. Float-product	−100 +200	11.1	3.6	88.3	3.4	
solids, pct, 50.1	−200	11.7	3.9	100.0	3.4	
Refuse. Weight by differ-	14 to 0	100.0	9.1	100.0	9.1	
ence 62.7 lb, dry basis.						

* Moisture-free basis.
In the above set of tests the increase in weight recovery of float coal due to the presence of the baffle blocks was 51.2 pct.

Table V. Comparative Tests of Coal from the Mary Lee Bed, With and Without Supercharging

Product	Screen Size, Mesh	Weight, Pct	Ash,* Pct	Cumulative Weight, Pct	Cumulative Ash,* Pct	Power, Watts
Flotation feed.	−14 +28	34.3	38.5	34.3	38.5	
ROM crushed to	−28 +48	25.0	31.1	59.3	35.4	
14 mesh. Weight	−48 +100	15.4	29.1	74.7	34.1	
132 lb, dry-	−100 +200	10.1	28.3	84.8	33.4	
coal basis.	−200	15.2	33.7	100.0	33.4	
Float coal, with	−14 +28	21.7	8.1	21.7	8.1	With super-
supercharging at 9 in. water	−28 +48	23.2	8.9	44.9	8.5	charging im-
gage. Weight 36.0 lb,	−48 +100	21.3	9.5	66.2	8.8	peller required
dry-coal basis. Float-	−100 +200	15.6	9.8	81.8	9.0	760 w.
product solids, pct, 44.4	−200	18.2	10.2	100.0	9.2	
Refuse. Weight by differ-	14 to 0	100.0	42.5	100.0	42.5	
ence 96.0 lb, dry basis.						
Float coal, without	−14 +28	22.7	8.0	22.7	8.0	Without super-
supercharging. Weight	−28 +48	29.4	9.0	52.1	8.6	charging im-
43.1 lb, dry-coal	−48 +100	20.9	9.9	73.0	8.9	peller required
basis. Float-product	−100 +200	13.2	10.3	86.2	9.2	1060 w.
solids, pct, 46.9	−200	13.8	11.2	100.0	9.4	
Refuse. Weight by differ-	14 to 0	100.0	45.1	100.0	45.1	
ence, 88.9 lb, dry basis.						

* Moisture-free basis.
In the above tests, supercharging decreased the weight recovery of float coal by 16.5 pct.

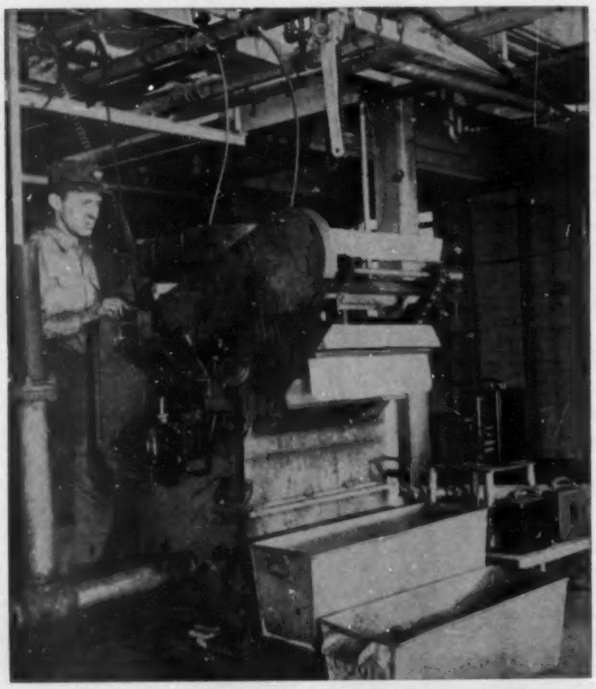

Fig. 1—Front view of flotation cell. Dry coal, water, and reagents are all fed through a pan-type intake to the feed pump. A Sturtevant blower furnishes air for supercharging.

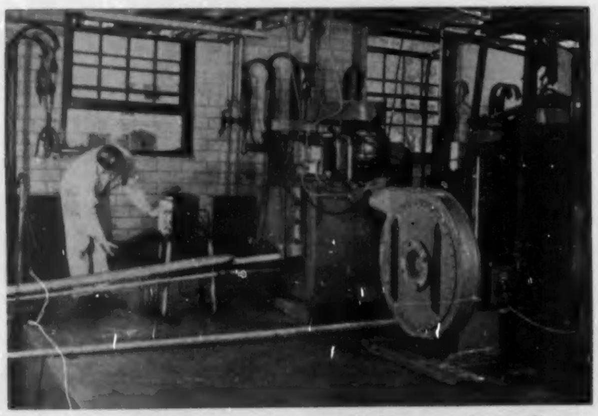

Fig. 2—Flotation cell, rear view, with blower and recording wattmeter.

two samples of coal, one from the Mary Lee and one from the America bed. The supercharging process consists of introducing air under pressure into the impeller area on the assumption that in this way a greater amount of pulp aeration will be obtained and that this will, in turn, increase the rate of flotation. In the present investigation, a centrifugal blower was connected with the impeller standpipe, and a valve and manometer were installed so that any desired pressure could be maintained.

Contrary to what might have been expected, supercharging decreased the float coal recoveries by 16.5 pct on the Mary Lee coal and by 6.4 pct on the America coal. Table V shows results of the tests. The data on the refuse were arrived at by the same method as in Tables I to IV. During the supercharging tests there were no baffle blocks in the cell, and all variables were kept the same as they had been for the previous runs recorded in Tables I to IV. The flotation sample in Table V was different from those in Table I, and although they were all from the same mine on the same bed, their flotation characteristics were quite different.

Miscellaneous Tests: A series of tests was made in which the percentage of solids in the flotation feed was varied. All other variables were kept constant and at the same rates and magnitudes as in the previous runs, recorded in Tables I to V. There were, of course, no baffle blocks in the cell and no supercharging. The tests were made on a sample of run-of-mine coal from the Mary Lee bed crushed to 14 mesh, with a head-ash analysis of 29.7 pct. The percentage of solids in the feed ranged from 10.2 to 22.3 pct. The solids percent and the weight recoveries on a dry-coal basis were as follows:

Solids in Feed, Pct	Float Coal, Lb
10.2	49.9
14.6	69.5
18.7	75.9

In the test with 22.3 pct solids, the float-coal weight was 75.9 lb (the same as at 18.7 pct solids), but the sand pipe choked up abou: 2 min before the feed coal ran out, probably increasing the amount of float coal by increasing the retention time of coarse particles towards the end of the run. Obviously the above figures are only indicative and not

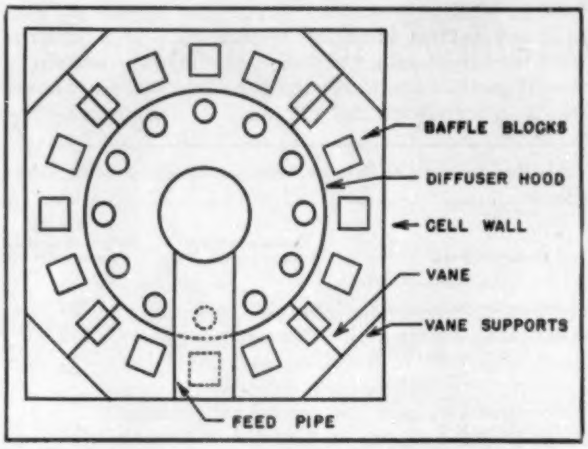

Fig. 3—Line drawing of cell bottom showing position of baffle blocks.

factually representative of the relation between feed solids and float coal recovery because the tests were of the batch type, in which the percentage of solids is zero at the start of the test and almost zero again at the end. This probably results in reducing the effective percentage of solids considerably, which in turn would mean that the figures for percentage of solids in the feed, shown above, would also have to be reduced to be representative of continuous operating conditions. Taking this into consideration, it seems likely that the peak of float recovery would be at a point less than 18 pct solids in the feed.

In another set of tests, made on Pocahontas coal under standard conditions, the pulp level was varied to give cell depths from 17 in. for one test to 28 in. for another. At the 28-in. depth, float coal recovery was 5.2 pct greater than at a depth of 17 in.

One test has been made on Pocahontas coal in which a 24x24-in. perforated plate with 3/16-in. holes and 23 pct open space was installed horizontally in the cell 4 in. below the surface of the pulp. This was done in an effort to reduce *boiling* and turbulence at the pulp surface on the assumption that to do so might increase flotation rate. In two parallel tests under standard conditions, the use of the perforated plate reduced the weight of float coal recovered 23.3 pct below what it was without the plate.

Float Product Quality: Ash analyses of float products have not been considered important in this investigation. In the first place, as already explained, ash-reduction efficiency of the coal-flotation process in the Birmingham district is satisfactory, and the only problem is to increase the float recovery rate so the feed rate can be stepped up proportionally. In the second place, the analyses in Tables I to V show that although increases in float recovery are always accompanied by higher ash the increases in ash are about what might be expected on the basis of the usual *yield-ash* relationship.

Float-and-Sink Data on Samples of Flotation Feed: Since no attempt has been made to obtain complete recovery of coal fed to the flotation cell, detailed information regarding washability characteristics has not been considered necessary in this investigation. In flotation experiments with the unit cell, the coal is fed at almost as high a rate as the rate at which it would be fed to a 4-cell bank when complete recovery of coal is desired, and the weight of coal recovered in the float product by the unit cell is used as the criterion of performance. However, to give some idea of the types of coal that have been used as flotation feeds, Table VI shows float-and-sink tests of three samples representing the feeds referred to in Tables II and III and the lower section of Table I.

Discussion of Results: To present in better perspective the effects of using the baffle blocks, Table VII summarizes the runs concerned with this variable. Benefits obtained from the blocks varied over a wide range with different flotation feeds. The percentage increase in the float coal due to the blocks varied from 15.8 to 51.2 pct. Throughout the tests there has been a strong indication that the easier the coal is to float the greater the benefits from the blocks, and vice versa.

Undoubtedly everyone recognizes that different coals and different types of coal vary enormously in floatability characteristics. It has been the authors' experience in the Birmingham district that, other things being equal, the more impurities a coal contains, whether bone coal or simply rock, the harder it is to float. Float-and-sink data in Table VI indicate that, on this basis at least, the order of floatability for these three coals would be Kelly, Mary Lee, and America. The Pocahontas coal, on which no float-and-sink tests were made, contained almost no bone or rock, and being also a low-volatile coal it appeared to have all the characteristics needed to make it extraordinarily easy to float. Table VII shows that the benefits from the baffle blocks decreased in this same order, namely, Pocahontas, Kelly, Mary Lee, and America. The crushed Mary Lee coal in Table I does not fit well in this picture, but a crushed flotation feed is often easier to float than a feed of the same size screened out of the original raw coal, and this might be the reason for the observed discrepancy.

Table VII shows that the baffle blocks reduced the power requirements of the flotation cell impeller considerably in all tests. Although there has been some theorizing from time to time that flotation is a power process, these results seem positive evidence that a great deal depends on the way the power is applied.

The data in Table V on the supercharging tests will no doubt surprise those who have been con-

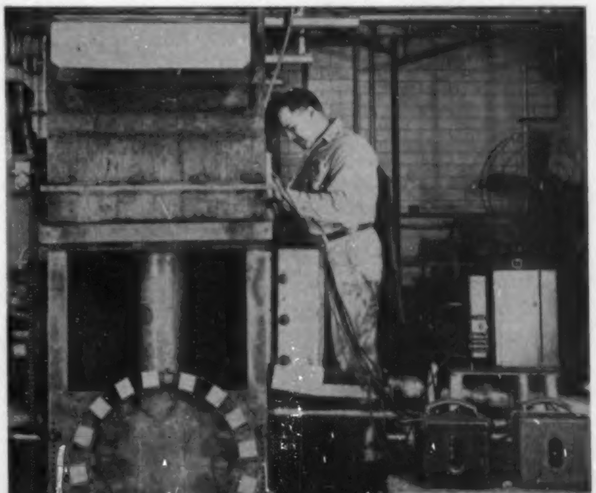

Fig. 4—Flotation cell, with adjustable front wall open and baffle blocks outside.

cerned with the flotation process for fine coal cleaning. The theory of supercharging has been that it speeds the flotation process and increases capacity of the cells. The data in the present tests show, however, that supercharging decreased recovery of float coal by 16.5 pct on Mary Lee coal and by 6.4 pct on America coal.

Table VI. Float-and-Sink Data of Flotation Feeds

Description	Sp Gr	Weight, Pct	Ash,* Pct	Cumulative Weight, Pct	Cumulative Ash,* Pct
Mary Lee bed. 14 mesh to 0 screened out of ROM	Float on 1.25	14.8	1.8	14.8	1.8
	1.25 to 1.30	38.6	5.8	53.4	4.7
	1.30 to 1.38	19.6	13.7	73.0	7.1
	1.38 to 1.50	9.9	20.9	82.9	8.8
	1.50 to 1.70	4.6	37.7	87.5	10.3
	1.70 to 1.90	1.6	48.1	89.1	11.0
	Sink in 1.90	10.9	80.7	100.0	18.5
Kelly bed. ROM crushed to 14 mesh	Float on 1.26	52.5	2.1	52.5	2.1
	1.26 to 1.30	32.8	4.5	85.3	3.0
	1.30 to 1.38	7.4	9.6	92.7	3.5
	1.38 to 1.50	3.0	15.1	95.7	3.9
	1.50 to 1.70	1.5	25.5	97.2	4.2
	1.70 to 1.90	0.4	47.9	97.6	4.4
	Sink in 1.90	2.4	74.6	100.0	6.1
America bed. 14 mesh to 0 screened out of ROM	Float on 1.30	24.4	5.1	24.4	5.1
	1.30 to 1.38	16.9	11.6	41.3	7.8
	1.38 to 1.50	13.2	20.1	54.5	10.7
	1.50 to 1.70	10.9	34.3	65.4	14.7
	1.70 to 1.90	6.0	51.7	71.4	17.8
	Sink in 1.90	28.6	81.2	100.0	35.9

* Moisture-free basis.

In the tests at different pulp levels results were in line with accepted theory, but the magnitude of variation was far from what might have been expected. They show how fallacious it would be to assume a more or less direct relationship between cell volume and cell capacity. At the 28-in. pulp level the effective volume of the cell was about 1.6 times as great as at the 17-in. level, but float coal recovery was increased only 5.2 pct.

Summary and Conclusions

Operating variables and certain factors pertaining to cell design are being investigated for possible effects on coal flotation-cell capacities. A modified subaeration-type unit cell, 24x24-in. cross-section, volume 12 cu ft, is used in the experimental batch-type tests. Some of the significant findings are:

1) A set of baffle blocks placed in the bottom of the cell, concentrically around the impeller diffuser hood, has increased recovery of float coal by amounts from 15.8 to 51.2 pct on different types of flotation feed. In these tests the power requirements of the impeller were reduced in amounts varying from 12.5 to 17.8 pct.

2) Supercharging in tests on two different feeds reduced the recoveries of float coal 16.5 and 6.4 pct, respectively.

3) In two parallel tests at cell depths of 17 and 28 in., float coal recovery at 28-in. depth was only 5.2 pct greater than at 17-in. depth.

The significance and the explanation of these results are as yet uncertain. It is surprising that the use of baffle blocks around the impeller can bring about such large increases in the amount of float coal, and it is equally surprising that supercharging had the adverse effect of decreasing float recovery. These results with baffle blocks and with supercharging may indicate that the all-important thing about aeration is efficient utilization of the air already dissolved and entrapped in the pulp, rather than aeration obtained by introduction of air from external sources. Baffling might promote a condition in which continuous circulation of the pulp in and out of the impeller results in points of frequently alternating pressure and partial vacuum, a condition that would release the dissolved air, allowing it to transport coal particles to the surface. The Elmore vacuum-flotation process is ample proof that enough air is dissolved and entrapped in the pulp for flotation purposes.

Table VII. Summary of Data on Beneficial Effects of Baffle Blocks

Flotation Feed	Increased Float-Coal Recovery, Pct	Decreased Power Requirements, Pct*
Mary Lee bed ROM crushed to 14 mesh	33.6	15.7
14 mesh to 0 screened out of Mary Lee bed ROM	35.7	15.4
Kelly bed ROM crushed to 14 mesh	42.0	16.0
14 mesh to 0 screened out of America bed ROM	15.8	12.5
Washed ⅜ in. to 0 Pocahontas crushed to 14 mesh	51.2	17.8

* Impeller drive only.

No definite claims are made one way or another with regard to commercial applicability of these results. Cement blocks would probably not be wear-resistant enough to be practical for use in commercial machines. Blocks could be made of more wear-resistant material, however. There are, of course, several important differences between conditions under which these tests were made and those of commercial operation. In commercial operation a flotation cell operates on a fairly uniform feed, both as to tonnage and quality, whereas in these tests the solids in the cell ranged from zero at the beginning of the run to a normal load and then back to almost zero at the end. Furthermore, the tests were made on 14-mesh to 0 feeds, whereas in most commercial plants the feed is much finer and usually deslimed. In commercial plants the cells are usually much larger, too, than the one used in this investigation. In spite of such discrepancies, however, it is hoped that results of this investigation will indicate methods of attack whereby flotation cell capacities in commercial plants can be increased.

Acknowledgments

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References

[1] Howard W. Griffiths: The Cleaning of Run-of-Mine Coal by the Chance Sand Flotation Process and Froth Flotation. *Second International Coal Preparation Congress*, Steinkohlenbergbanverein, Essen, Germany, September 1954, Contribution A II 4, 5 pp.

[2] L. E. Schiffman: Kerosene Flotation of Bituminous Coal Fines. Mining Engineering, 1950, vol. 187, no. 10, pp. 1047-1057.

[3] B. W. Gandrud and H. L. Riley: Recent Developments in Combination Cleaning and Dewatering of Fine Sizes of Coal. U. S. Bureau of Mines *R. I. 4707*, 1950, 28 pp.

[4] L. E. Schiffman and E. D. White: Floating Fines with Kerosene. *Coal Age*, vol. 56, March 1951, pp. 78-82.

[5] B. W. Gandrud and L. E. Schiffman: The Kerosene-Flotation Process for Fine-Coal Cleaning and Dewatering. *IV Congres International Du Chauffage Industrial*, 2 Rue des Tanneries, Paris, Group II no. 213, 1952, 8 pp.

Comments on Evaluation of the Water Problem At Eureka, Nev.

by C. B. E. Douglas

The following analysis was stimulated by a previous article on evaluation of the water problem at Eureka, Nev., which describes a method using formulas especially devised to calculate flow potential of extensive aquifers characterized by relatively even porosity and permeability throughout. The present discussion submits that the method was unsuitable for solving the kind of problem occurring at Eureka, where the amount of water available, rather than the flow potential, may have been the vital factor.

IN an interesting article on evaluation of the water problem at Eureka, Nev.,[1] W. T. Stuart describes how a difficult water problem, or one phase of it, may be evaluated by means of a small scale test. Test data are plotted by a method rendering, under certain conditions, a straight-line graph that can be projected to show how much the water table will be lowered by pumping at any specified rate for a given time. A formula is then used to determine the size of opening, or extent of workings, necessary to provide sufficient inflow to enable pumping to be maintained at that rate.

At first glance this might seem the answer to a miner's prayer, but a word of caution is in order. It may not be the whole answer. Moreover, results obtained by the method described are reliable only for conditions approximating those assumed. Even where conditions do not meet this requirement, however, it may be possible to draw helpful inferences from the results, perhaps enough to facilitate another approach to evaluation of a problem.

The two formulas Mr. Stuart used, the Theis formula and the one developed from it by Cooper and Jacob, were given field checks a number of years ago in valley alluvials by the Water Supply Div. of the U. S. Geological Survey and found to be reliable when the aquifer is very large in horizontal extent and sufficiently isotropic for the test well and observation wells to be in material of the same average permeability as the saturated part of the aquifer as a whole.[2]

Extensive valley alluvials, sands, and gravels can be evaluated in this way, and there are even cases in which the method could apply to porous limestones, such as flat beds of very large areal extent that have been submerged below the water table after extensive weathering. These are sometimes prolific sources of water for towns and industries. It is necessary for them to have been above the water table for some geologically long period of time in a fairly humid climate before submergence because the necessary high porosity and permeability, and large reservoir capacity, are the result of weathering, that is, of solution by the carbonic acid (H_2CO_3) in rainwater formed by the absorption of CO_2 from the air by raindrops, and this dissolving action must cease when all the H_2CO_3 has been consumed by reaction with the carbonate to form the more soluble bicarbonate. Consequently this weathering process is largely restricted to a zone that does not extend much below the water level, and submergence is necessary after the weathering to provide large reservoir capacity and good hydraulic continuity.

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Discussion of this article, TP 4155A, may be sent (2 copies) to AIME before Feb. 29, 1955. Manuscript, May 4, 1955.

On the other hand, water courses tend to form along faults and fractures in limestone, and to become enlarged by solution, well below water level when, as often happens, fresh meteoric water is circulated rapidly through them to considerable depth by hydrostatic pressure, as through an inverted syphon. Although the reservoir capacity of such water courses is relatively small they may extend far enough to tap more prolific sources.

Cavities, and sometimes caves of considerable size, are found in limestones where the acid formed by the oxidation of sulphides has attacked them. This action can take place as deep below water level as surface water is carried by syphonic or artesian circulation, because the oxygen it carries in solution will not be consumed until it reacts with some reducing agent, such as a sulphide. Moreover, the formation of acid and solution of limestone in this way is not confined to the immediate vicinity of the sulphide. Oxidation of pyrite, for example, results in formation of acid in several successive stages, each taking place as more oxygen becomes available, as by the accession of fresh water into the circulation at some place beyond the sulphides. When the acid thus formed attacks the limestone, CO_2 is liberated and the ultimate effect of the complete oxidation of one unit of pyrite will be the removal of six times its volume of limestone as the sulphate and bicarbonate, both of which are relatively soluble. The reaction may be continued or renewed along a water course far from the site of the sulphides, where the small electric potential produced by contact with the limestone helped to start the reaction.

Mr. Stuart refers[3] to caves in the old mining area in the block of Eldorado limestone southwest of the Ruby Hill fault at Eureka, Nev., and to the cavities encountered in drillholes in the downthrown block on the other side of the fault. Although he interprets these cavities as evidence that this formation was sufficiently isotropic (evenly porous and permeable) to give reliable results by the method he describes, they may, in fact, be entirely local conditions. There is reason to think they were probably formed

largely, if not entirely, as a result of the oxidation of sulphides, and neither they nor the large water courses now known to exist can be considered proof that a high degree of general porosity, indicating large reservoir capacity, is a characteristic of this formation at Eureka. Monographs by Hague and Curtis, published by the USGS in the 1880's, do not describe the formation as having been rendered porous and cavernous by weathering away from the zone where oxidized ore was mined.

In considering the possible reservoir capacity of the Eldorado limestone it is also pertinent to note that the part of that formation that has been observed at Eureka has been folded, faulted, intruded, and elevated into and above the younger formations that surround it. It has not, therefore, the attitude, the continuity, or the areal extent down to moderate depths below water level to be a prolific aquifer, and much the same may be said of the other limestones in the immediate vicinity of the mine.

Consequently, the heavy pumping done in 1948* must be taken as evidence that the water courses that had been tapped extend out into other areas and other formations where there is larger reservoir capacity, with hydraulic continuity from one formation to another provided by faults, either serving as connecting links or making continuity of a solution channel possible by bringing limestones of different age into juxtaposition.

* 8000 to 9000 gpm in November and December, 1948—1.7 billion gal in five months.

Use of data from an actual test on a property that has received a good deal of publicity on account of the seriousness of its water problem renders Mr. Stuart's description of the method more interesting and easier to understand. It seems to the present writer, however, that in order to show how very helpful data from a relatively small scale test may be under certain conditions, Mr. Stuart has had to attribute properties to the formations at Eureka that they do not really possess. It may serve to put others faced with similar problems on guard if attention is drawn to certain features indicating that conditions are unsuitable for application of this method.

For example, the writer believes that Mr. Stuart's Figs. 4 and 6 do not show quite the sort of fit with the type curve that would indicate the kind of general porosity and hydraulic continuity the theory calls for—the irregularities appear too great. Nor do the straight-line graphs in his Figs. 5, 7, 9 and 11 appear to be much better in that respect—too many straight lines with different slopes can be drawn through different sets of points.

It is to be presumed that the Fad shaft data and graphs (Mr. Stuart's Figs. 4, 5, 6 and 7) are only used to provide a figure that is needed for the example he gives to show how the time and rate for unwatering may be calculated, because the lower part of the shaft, as he points out, is in impermeable shale and nowhere is it in the Eldorado limestone; the flow of water into it comes mainly from the water courses tapped in the vicinity of the Martin fault on the 2250-ft level and does not result from the general infiltration the theory calls for. The size of the shaft and the amount of surface exposed on the level have nothing to do with rate of inflow. It is known that the 1685 station was recovered 26 days after pumping was resumed on Feb. 1, 1953, by pumping an average of only about 4050 gpm, whereas application of the method described by Mr. Stuart to the test data shows it should have required pumping at the rate of 6000 gpm for 450 days, see his Table III. At the same time it should be pointed out that variations in the freedom of flow into the Fad shaft have very little bearing on the rate of pumping that would be necessary to drain the orebody.**

** There is good evidence that wide variations in the flow into the Fad shaft were caused by choking (due to caving) and flushing at the point of entry into the 2250 level.

It was to be expected that pumping would affect the water level in diamond drillholes *E* and *F* in much the same way because they are both about 1000 ft from the shaft and only about 400 ft apart laterally, not far from important faults and in an area where some oxidation of sulphides is known to have taken place and where drillholes encountered cavities. The graphs for these two holes in Mr. Stuart's Figs. 8 and 10 match the type curve very well, not only for a segment but for their whole length, but before accepting this as proof that the aquifer is of the kind it is assumed to be, it is interesting to note what the straight-line graphs for them in his Figs. 9 and 11 indicate in this respect. They show that straight lines can be drawn through several separate series of points, each with a different slope. Consequently they give several quite different figures for the amount of drawdown corresponding to a logarithmic cycle that has to be substituted in the formula, instead of only the one that gives the same value for T (the transmissibility) as was derived from matching the other kind of graphs with the type curve (Mr. Stuart's Figs. 8 and 10).

Mr. Stuart refers to one change to a steeper slope in the straight-line graphs in his Figs. 9 and 11, the change occurring about the 20th day of the 30-day drawdown test, as evidence that the expanding inverted cone of depression in the water table caused by the pumping had reached a barrier which prevented the flow to the point of withdrawal from that direction from increasing as fast with depth as it otherwise would have. There was thus a somewhat more rapid drawdown than would have occurred in the succeeding ten days had there been no change in the aquifer to affect it. A much more significant feature of these two graphs, however, is the pronounced progressive steepening of the slope with increasing depth, and this with a total drawdown in these two holes (*E* and *F*) of only about 100 ft.

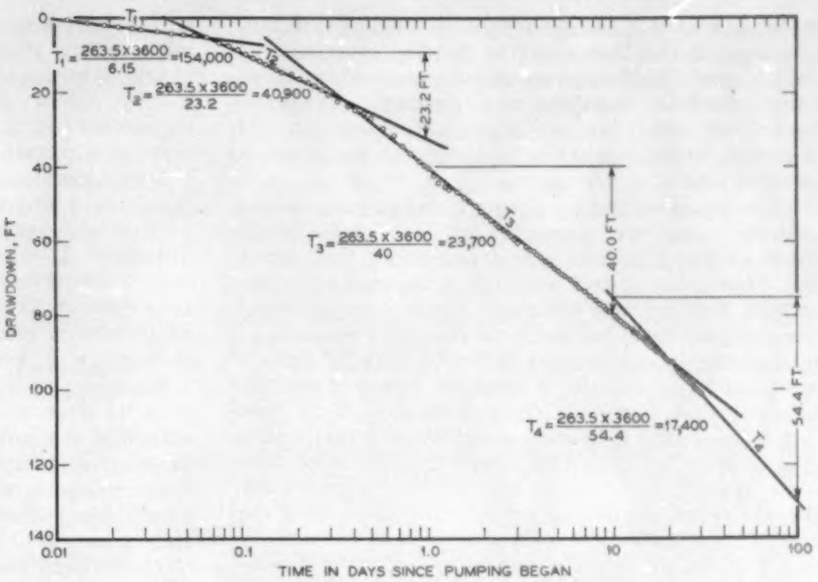
Fig. 1 of this paper is another graph made from the same data for *E* hole as were used by Mr. Stuart for the graph in his Fig. 9 and plotted in the same way. On it three additional straight lines have been drawn through three other series of points, including those representing the drawdown-time relation for the last ten days of the drawdown test, and the corresponding values for T, the transmissibility, for different depth ranges, as shown below:

Transmissibility	Depth of Drawdown, Ft	Corresponding Value of T, Gpd
T_1	1.11 to 5.67	154,000
T_2	5.67 to 19.59	40,900
T_3*	24.88 to 92.82	23,700
T_4	92.82 to 101.24	17,400

* The line from which T_3 is calculated is intended to be identical with the line shown in W. T. Stuart's Fig. 9. Still another value for T, intermediate between T_2 and T_3, might be obtained from the slope of a line drawn through the more irregular series of points covering the drawdown from 19.56 ft to 46.90 ft.

The above values for T indicate a remarkable series of increases in the rate of drawdown from

Fig. 1—The graph shown at right is constructed from the same data for *E* hole as were used by W. T. Stuart in his Fig. 9 (*AIME Trans.*, February 1955, page 153) and is plotted in the same way. Three additional straight lines have been drawn through other series of points. See data given on opposite page.



what would be expected in the case of an isotropic aquifer of large extent. They might perhaps be explained by assuming that the expanding inverted cone of depression had reached one effective barrier after another, each naturally in a different direction. This, in turn, would mean that the cone of depression had successively reached a corresponding number of limits restricting the size of the reservoir area. But a similar effect could be caused by progressive decreases in the permeability or porosity with depth below the natural water table, which, from what has been said in the foregoing about the weathering of limestones, would be a reasonable expectation. In fact, anything that prevented the flow to the point of withdrawal from increasing as rapidly with increasing depth as would be expected in the case of a very extensive, homogeneous, isotropic aquifer would cause slope of graph to become steeper and value of T calculated from it to become smaller. Such changes in slope caused by barriers should tend to be rather abrupt and those due to a general decrease in permeability and porosity with depth less so, but in neither case should they be numerous. Successive drainage of porous beds in fault blocks, however, might produce many sharp changes in the steepness of the slope. If the recharge into the immediate reservoir area, or any important part of the recharge, should not increase with the depth of the drawdown, the graph should take the form of a curve with increasingly steep slope. If the rate of recharge increased normally with depth down to a certain point and then an important part of it became constant, there should be a relatively sharp change in the slope of the graph at that depth, with progressive steepening thereafter.

The magnitude of the favorable changes with depth indicated by the present author's graph and the foregoing values of T, with such a small total drawdown, stimulates speculation as to how much more favorable for the unwatering the conditions may be found to be at progressively greater depths.

The Cooper and Jacob formula, which was used to calculate these transmissibilities (for T_1 to T_4), is $T = \frac{263.5Q}{s_2 - s_1} \times \log_{10} \frac{t_2}{t_1}$ in which T is the transmissibility in gpday per ft, Q is the rate of pumping in gpm and s_2 and s_1 the drawdown at times t_2 and t_1. In one logarithmic cycle of time $t_2 = 10 \times t_1$ and log t_2/t_1 is 1. The formula may then be abbreviated to $T = 263.5\ Q/s$ in which s represents what the drawdown would be in one logarithmic cycle of time as indicated by the straight-line graph. It was developed from the Theis formula to simplify the calculation of transmissibilities and to facilitate extrapolation. It will be noticed that the Cooper and Jacob formula includes no factor to take care of the time lag for the effects of pumping at a constant rate to become manifest at a point of observation some distance away from the point of withdrawal, nor for the decrease in total amount of the drawdown as distance from the point of withdrawal increases. This time lag must cause the drawdown at such a point of observation to start slowly and to progress at an increasing rate until a maximum rate of drawdown is attained, when the full effect of the pumping reaches there, after which the rate of drawdown should decline steadily, in inverse proportion to the logarithm of the time.

During the period between the first manifestation of any effect of the pumping and attainment of the maximum rate of drawdown, the graph plotted by the Cooper and Jacob method will not be a straight line, but should be a smooth curve, the slope increasing with time, and transmissibilities calculated from the slope of a straight line tangent to any part of it will be too high but will decrease as the slope becomes steeper. After the effects of the pumping become fully reflected there and the rate of drawdown has reached its maximum, the shape of the cone of depression in the water table caused by the pumping, as it would appear in a cross-section, would be expected to remain constant between the point of withdrawal and the point of observation, and the time-drawdown graph should become a straight line, except for the effect of barriers, changes in permeability, etc.

It follows that this time lag for the effects of the pumping to be fully reflected at a distant point of observation will decrease in duration as the permeability, and therefore the transmissibility, of the aquifer increase and vice versa.

Mr. Stuart has calculated[4] that with a transmissibility of 24,000 gpd it should have taken 2.8 days for

the shape of the assumed cone caused by the test pumping in the Fad shaft to become stabilized at hole *E*, about 1000 ft away, and for transmissibilities calculated from the slope of the straight line time-drawdown graph by the Cooper and Jacob formula to become reliable, that is, for the graph to become a straight line.

This transmissibility figure, 24,000 gpd, would indicate quite low permeability in an aquifer as thick as the Eldorado limestone. From this figure Mr. Stuart calculated[6] that for a theoretical winze at hole *E* to provide sufficient water to supplement the pumping from the shaft the desired amount (i.e., by 10,030 gpm maximum) it would have to have a radius of 50 ft, i.e., 100 ft in diam. Hence it may be inferred that a well 1 ft in diam drilled to that depth (over 1200 ft below normal water level) would supply only 1 pct of that amount. This may help some readers to visualize the sort of permeability the above transmissibility figure indicates, and the sort of time lag to be expected from it 1) before any effect of the pumping would be manifest in *E* hole and 2) before the maximum rate of drawdown would be attained there.

It is interesting to compare the impressions thus created with what actually happened. According to the tabulated records the first reading taken in *E* hole showed that the water level was already falling there only 1 min after the test pumping started in the Fad shaft and successive readings indicate that the maximum rate of drawdown was attained between 10:05 and 10:10 that morning, that is, within 17 min or 0.012 of a day from the start of the pumping. During the next 15 min there was some irregularity in the rate of drawdown indicated but thereafter, that is, after 32 min or 0.022 of a day from the start of the pumping, the rate of drawdown in *E* hole declined continuously, leaving no room for doubting that the maximum had been passed.

The first point in Fig. 1 of the present paper represents the drawdown 0.012 of a day (17 min) after the pumping started. It is the first of the 11 points that determine the slope of the line marked T_1; the one at 0.022 of a day, which falls right on the line, is the fourth. It therefore seems reasonable to assume that the changes in the slope of the graph thereafter, that is, from T_1 to T_4, are effective indicators of proportional changes in the transmissibility and not the effects of the time lag mentioned, as it would be natural for Mr. Stuart to infer from his calculations and even from the general shape of the first part of the graph.

That the reaction of the water level in *E* hole to the start of the pumping was almost instantaneous is supported by the increasing rate of drawdown shown by the second reading, taken 2 min after the first, and succeeding ones. This is interpreted as indicating an open water course between the drill-hole area and the place where flow into the 2250 level is restricted. Likewise, the comparatively long time for the full effect of the pumping to become manifest in *E* hole—between 12 and 17 min (or between 27 and 32 min?)—is ascribed to the peculiar nature of the restriction, which is believed to be a choking effect by caved material, some of which evidently came down during the four-year interval between the flooding in December 1948 and the beginning of the drawdown test in December 1952.

The amount of water that has to be removed to drain a mine usually involves several factors. A certain amount of reservoir water has to be removed while at the same time taking care of the recharge into the area affected by the drainage. Ultimately, under continuous pumping, only the recharge will have to be handled to hold the water level at a certain depth at the point of withdrawal.

Three kinds of recharge may be considered, more than one of which may occur in any particular case: 1) that originating within the area affected by the drainage, as direct infiltration from the surface overlying the area; 2) general permeation into the area through its periphery; and 3) flow confined to a subterranean channel or channels connecting with some more or less distant source.

Recharge of the first kind can usually be evaluated, at least to some extent, from the horizontal extent of the area affected or to be affected by the drainage and the balance between precipitation, on the one hand, and evaporation and runoff on the other, supplemented if need be by measurements and tracers to check what may be absorbed from streams flowing across the area. Where the area is limited in size recharge from precipitation on it will be correspondingly limited. Both that and infiltration from stream beds will be independent of the depth to which the water level in the mine may be lowered.

Recharge due to general permeation into the area around its periphery will increase progressively with the depth to which the water level is lowered in the water-bearing formation if that formation is very extensive and is equally permeable at all depths. This is the kind of situation that can be evaluated quantitatively by the method described by Mr. Stuart, which is based on the coefficients of storage (S), or free reservoir capacity, and permeability, factors that are usually interrelated to some extent, and the answers are all based on the assumption that the aquifer is isotropic and that the amount of free reservoir water available is infinite, or so large that for practical purposes it may be considered so.

If the free capacity of the local reservoir area is not very large and recharge of the third kind is the principal one involved, as there is reason to think may be the case at Eureka, Nev., the most important factors will be the supply available in the place the water comes from, the elevation of the highest point along the course of the channel, and the flow capacity of its smallest part. No more water can flow through the channel than the fixed head behind the highest point will cause to flow over the hump or through the part of greatest restriction, and these two factors therefore provide limits beyond which the rate of flow from that source cannot increase as the depth of the drawdown in the area into which the water flows increases.

If the recharge into an area is less than the rate at which water is being removed from it by pumping, that area must ultimately become drained to the point where only an amount equal to the recharge will have to be handled. In that case the quantity of free reservoir water that has to be removed and the rate of recharge into the area become the most important factors, rather than the magnitude of the flow which would be determined by the permeability of the formation (or the size of the water courses) if enough water were available.

Where flow through channels or water courses from a more distant source is an important factor in the recharge of a local reservoir area, the free reservoir capacity of that source and its rate of recharge

may be of vital importance, thereby presenting a problem requiring tests and studies of different kinds, with no assurance that a satisfactory solution will be found.

Before these comments are closed, the following statement made by Mr. Stuart[6] seems to call for qualification because it would be valid only under the idealized conditions he assumed:

> Fig. 13 is a time-drawdown graph for a pumping rate of 1000 gpm at the Fad shaft. In as much as drawdown is proportional to rate of withdrawal, the graph was constructed by use of 1/3.6 of the measured drawdown in the 30-day test.
> (Note: The rate of pumping is reported to have been 3600 gpm and 1000 gpm is to 3600 gpm as 1 is to 3.6)

This assumption, that the drawdown is directly proportional to the rate of pumping, is the one on which he bases his calculations of the pumping rates and times for the unwatering of the Fad shaft and orebody. It is not supported by any evidence and it should be pointed out that it is not valid if any important part of the recharge into that area is constant, or is subject to some control different in type from the coefficient of permeability of an infinitely large isotropic aquifer, such as direct recharge from the surface or recharge through a long pipelike conduit. It may help to visualize this point if, as an extreme sort of example, an area it is planned to drain be likened to a tank, say one with a horizontal cross-section of 100 sq ft, fed by a constant inflow (or recharge) of 750 gpm, or 100 cfm. Normally an amount equal to its recharge will overflow and pumping at the rate of 750 gpm would stop the overflow but would not lower the water in the tank noticeably; pumping 10 pct faster, or 825 gpm, would lower it at the rate of one tenth of a foot a minute but increasing the pumping rate to twice as much, or 1650 gpm, would cause a drawdown *twelve times as great* (instead of twice as great), as shown below:

1—Capacity of tank per foot of depth	750 gal	750 gal	750 gal
2—Inflow into tank or recharge	750 gpm	750 gpm	750 gpm
3—Assumed pumping rates	750 gpm	825 gpm	1650 gpm
4—Available for drawdown: pumping rate less recharge	0	75 gpm	900 gpm
5—Drawdown per min (line 4 divided by line 1)	0	0.1 ft	1.2 ft

Although it may not yet be possible to apply precise mathematical methods to the solution of water problems complicated by physical irregularities in the formations and more than one kind of recharge into the area it is desired to drain, such articles as Mr. Stuart's encourage the hope that effective progress will be made towards that end. The article is a lucid description of how one type of water problem may be evaluated.

References

[1] W. T. Stuart: Pumping Test Evaluates Water Problem at Eureka, Nev. *AIME Trans.*, February 1955, vol. 202, pp. 148-156.
[2] L. K. Wenzel: Methods for Determining Permeability of Water Bearing Materials with Special Reference to Discharging-Well Methods. *USGS Water Supply Paper 887*, Washington, D. C., 1942.
[3] Ref. 1, p. 148.
[4] Private communication from W. T. Stuart.
[5] Ref. 1, p. 154.
[6] Ref. 1, p. 152.

Discussion

Comments on the Evaluation of the Water Problem at Eureka, Nev.

by Wilbur T. Stuart

Mr. Douglas discusses the unwatering problem at Eureka from a viewpoint backed by many years of experience in mine water problems. He calls attention to the differences between the hydrology of the area and the assumptions of the well formulas used in the present writer's original paper to determine the size of the unwatering problem. It is a matter of opinion as to whether these differences are of importance, but it is the purpose of this discussion to show that where the differences are significant they were considered in the writer's computations.

New methods and new ideas always require considerable testing before they are accepted. Although the application of the well formulas to a mine shaft may be new, the formulas have been used with considerable success to determine the yield and drawdown in limestone, dolomite, sandstone, and other fractured rock formations. Application at the Fad shaft was but a step further under differing conditions, but it was made with some knowledge of what to expect.

The Theis nonequilibrium formula, as used in two ways in the original article, assumes a single formation, large in areal extent, which is both homogeneous and isotropic hydraulically. It assumes further that when the formation is pumped the water is instantaneously released from storage and no interformational leakage occurs. Similar conditions of uniformity are postulated for formations investigated by means of electrical-resistivity and seismic surveys. The practicability of making an interpretation depends, of course, on the degree to which simplifying assumptions are judged to be safe.

The writer's original paper considers all the water-bearing formations at Eureka to be one unit yielding water to the Fad shaft and the Eldorado dolomite, whereas it is known that each of several layers contributes water under head and flow conditions differing from those under which its neighbor contributes. Also, the local variations in permeability are integrated by consideration of large distances only. As an illustration, it is believed that any two randomly selected 1-ft cubes of a formation in place would be likely to have greatly different physical properties for transmission and storage of water. If, however, the sides of the cubes were increased to 1000 ft, the processes by which natural permeability is created, such as faulting, brecciation, folding and jointing, oxidation, and solution, should reach a *common denominator* by which the large difference for the small cubes would be reduced to a much smaller difference for the large ones. Furthermore, the averaging-out would be more effective as applied to adjacent horizontal cubes than as applied to adjacent vertical ones. Thus by choosing observation points at large distances in a pumping test, many of the local irregularities can be averaged. If the observation points are distributed in many formations throughout the area, coefficients for the average condition will be obtained which may be extended beyond

the area of influence of the short test, if the local geology and hydrology justify such an extension.

In the original paper the fitting of the nonequilibrium type curve in Figs. 4, 6, 8, and 10 and the selection of the particular line on the semilog plot in Figs. 5, 7, 9, and 11 are a matter of determining which average condition best fits the test data. Greater emphasis has been placed on the data for the longest time periods, even though the short periods occupy a large space on the logarithmic plotting. The type curves did not fit the data for the early time periods at Eureka, because the complex flow systems through the bedrock had not adjusted themselves to the common average condition that developed later.

The ideas of Mr. Douglas differ from those of the author in determining the proper position of the tangent line through the data in Figs. 5, 7, 9, 11, and 12. Mr. Douglas neglects a criterion for determination of this line. Cooper and Jacob[7] state that the expression for the drawdown in an observation well becomes linear for the semilog plotting after u is less than 0.02. Rewriting this, $t = 1.87\ r^2s/0.02\ T$, and solving for time in days ($T = 24{,}000$, $S = 0.0007$, $r = 1000$), it is determined that after 2.7 days the drawdown in the drillhole area should be linear on the semilog scale. Thus a tangent line matching the test data for drillholes E and F for time periods greater than three days after the pumping rate was changed satisfies this criterion. Accordingly, only the values of T_3 and T_4 as determined from the figure of Mr. Douglas are satisfactory. The last tangent, T_5, was interpreted in the writer's original paper as being caused by an impermeable boundary. The values of T_1 and T_2 given by Mr. Douglas are not mathematically justified.

Mr. Douglas suggests a series of progressively steeper tangents on the extension of the drawdown curves, possibly on the basis of diminishing rates of pumping he has observed in mines being unwatered. This diminishing rate conforms to the theory for a hydraulic system where the unwatering is continued to a given level and held at that point. The decreased yield is caused by the flattening of the hydraulic gradients that develop with time and should not be confused with decreased permeability. It may be caused in part by unwatering of the saturated materials, which decreases the area through which the water must pass. Because there is no hydrologic or geologic evidence of a decrease in permeability of the formations at depth at Eureka, the author has no mathematical or physical basis to justify anything but the straight lines used. The original paper states that as unwatering progresses the value for transmissibility probably would be reduced, thus causing a steeper extension. However, on the other hand, during the unwatering *the coefficient of storage* is expected to increase, thus flattening the extension. There is no known manner of foretelling whether these changes would cancel each other, as the time when the transmissibility will change and the rate at which the storage coefficient will increase are unknown. As a *hedge* to account for such changes, the author states that the construction of Figs. 13 and 14 is based on the assumption that the bedrock hydrology would not change materially as the cone of pumping extends beyond the limits considered in the 30-day test.

In discussing the transmissibility of the Eldorado dolomite and the yield of a winze 50 ft in radius, Mr. Douglas infers that a well 1 ft in diam would yield 1 pct as much as the flow from the winze. Actually the yields of wells in a given formation increase only slightly with increases in diameter. The yield of a winze 100 ft in diam would be only a few times as great as that of a well 1 ft in diam. On the other hand, experience with wells in rock formations indicates that it is not always possible to intersect sufficient water-yielding zones with a small bore to transmit the expected quantity of water. This is a difference between theory and practice, but it is not proof or lack of permeability of a rock unit, nor should the low yield of one or two small drillholes be taken to mean that an area is impermeable.

Mr. Douglas discusses three kinds of recharge as contributing to the flow of water to a mine. Of these, only one type—water entering the area as downward infiltration—is considered by students of ground-water hydraulics to be recharge. The other two types—general permeation of water through the periphery of the area, and flow confined to underground channels connected to distant sources—are essentially water flowing radially to the point of withdrawal in accordance with the infinite-aquifer theory used in the original paper.

Mr. Douglas attacks the statement that the drawdown is proportional to the rate of pumping, which is the basis for construction of Figs. 13 and 14 of the original paper. This direct proportionality—as an established mathematical relationship—may be observed in the Theis equation where both factors occur as first powers in the numerators on opposite sides of the equation. The tank illustration is offered as proof of nonproportionality; however, in that case, there is confusion between rate of unwatering and drawdown. The open tank is not duplicated underground in nature, as natural ground-water reservoirs are filled with materials that offer more or less resistance to the flow of water. In order to overcome this resistance and induce flow from one point to another, a hydraulic gradient is required. The difference in altitude that the discharge level is lowered below the original standing water level is the drawdown that produces the gradient inducing the flow. Thus, the greater the drawdown, the steeper the gradient, and the larger the induced flow. Drawdown is a function of the gradients developed in ground-water flow, not a function of the rate of unwatering. Darcy's law states that flow through a porous medium varies as the first power of the gradient, and innumerable tests on materials ranging from almost impermeable to highly permeable have verified the statement. This is another manner of stating that drawdown is proportional to the rate of pumping.

Data from the files of the Eureka Corp. Ltd. indicate that after the fissure was intersected on the 2250 level in 1948 the drawdown was approximately proportional to the pumping rate for ranges from 1000 to 9000 gpm during periods when the flow from the fissure was unrestricted. When the flow from the fissure was not free, a considerable range in drawdown occurred.

The hydraulic conditions of flow from the fissure are both unknown and unpredictable. They affect the calculations of the time required for unwatering by decreasing the time for unwatering the Fad shaft and increasing the time for unwatering the Eldorado dolomite, or vice versa. The 30-day drawdown test was made when the flow from the fissure was apparently free, and for that reason the results are believed representative of conditions normally expected during the complete unwatering of the property.

Mr. Douglas has expressed a number of opinions that differ from those of the writer in regard to evaluation of mine-water problems. He calls attention to the complexity of the geology and hydrology typical of mining districts and warns against placing blind faith in calculations. His warning is certainly justified; more information would always be useful in refining such calculations. So far as Mr. Douglas' other opinions on ground-water hydraulics are concerned, the writer believes that he has explained them according to accepted methods described in the literature. All the discussions emphasize the importance of adequate information, and it is hoped that many mining engineers having similar water problems will be in a position to obtain sufficient reliable data to be able to take advantage of the methods described.

Reference

[7] H. H. Cooper, Jr., and C. E. Jacob: A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History. *Trans. American Geophysical Union*, 1935, vol. 16, pp. 519-524.

Fluorochemical Collectors in Flotation

by Strathmore R. B. Cooke and Eugene L. Talbot

THE perfluoro acids and derivatives show unusual surface-active properties that qualify them as possible flotation reagents. They lower the surface tension of water from 15 to 20 dynes below that obtainable with the corresponding hydrocarbon compounds.[1,2] Fluorochemicals adsorb very strongly on solid surfaces to give films that exhibit larger contact angles than films of the corresponding hydrocarbons.[3,4] The large contact angles probably result from the terminal $-CF_3$ group.

The perfluoro acids are made by electrolysis of the corresponding carboxylic acid in anhydrous hydrogen fluoride.[5] From the perfluoro acids many derivatives may be obtained, such as amides, amines, alcohols, xanthates, ethers and esters and others.

Since the fluorinated analogues of the conventional hydrocarbon flotation collectors possess enhanced surface properties, a few were selected for testing. Because a survey of all possible minerals and reagent combinations would be out of the question, hematite was chosen to represent a nonsulphide system and pyrite to represent a sulphide system.

The fluorinated reagents used in these experiments were prepared in the research laboratories of Minnesota Mining & Mfg. Co. Some were synthesized especially for this research. They are not available commercially.

Separation of Nonsulphide Ores: The separation of oxides from silica has always been a challenge to the flotation industry because differences in surface properties of the minerals are normally insufficient to produce clean concentrates. Oleic acid,[6] rosin acids,[7] and amine salts[8] have been used to considerable extent to effect separation of metal oxides and silica.

The system hematite-silica was chosen to represent the nonsulphides both because of its difficulty of separation and because large tonnages of easily obtainable material are available, such as gravity concentration tailings and nonmagnetic taconites on the Mesabi Range.

The wash-ore tailings used here contained approximately 35 pct iron after desliming. Samples of the material used in this work were part of the same lot used by Chang, Cooke, and Huch[9] and were prepared in an identical manner.

Reagents for Nonsulphide Ores: Since one of the purposes of this investigation was to compare hydrocarbons with fluorocarbons, reagents of known behavior such as oleic acid, and the alkali metal salts of certain resin acids (Dresinates), were established as standards. Hydrocarbons and fluorocarbons of comparable chain length and other experimental fluorocarbons were tried as collectors for hematite. A list of the materials used and the concentrations of their stock solutions are given in Table I.

Since silica can be selectively floated from hematite by conventional reagents,[8] a few fluorocarbon reagents were also tried for this purpose. Their composition and concentrations are given in Table II.

Most of these reagents served the dual function of collector and frother. In the case of F-11 flotation did not occur but it served as a frother when F-6 was employed as a collector.

Reagent grade sulphuric acid and sodium hydroxide were used to regulate the pH. Deionized water containing less than 0.1 ppm of salts expressed as NaCl was used for all solutions and flotation tests.

The pneumatic flotation cell consisted of a 350-ml fritted glass Buechner funnel with a source of filtered air which could be controlled by a needle valve.[9]

A 50-g sample of ore and 250 ml of deionized water were added to the flotation cell and stirred slowly. The reagents were added and the pulp was conditioned before air was admitted to the cell. Approximately 15 ml of the pulp were removed for pH determination before flotation was started and were then returned to the system. The pH was again measured after flotation. Air was admitted to the cell until no further flotation occurred or until the character of the float changed markedly. Both the float and the nonfloat products were filtered, dried, weighed, and assayed for iron.

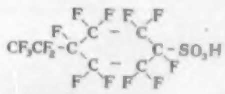
The cell was washed in hot water and rinsed with deionized water after each test. Occasionally the cell was cleaned with concentrated hydrochloric acid to remove iron oxide particles from the glass frit.

Experimental Results: Above a pH of 8, sodium oleate was an effective collector for hematite. The emulsification of equal parts of heavy fuel oil (20°

Table I. Flotation Collectors for Hematite

Reagent Composition	Concentration
Sodium oleate	5 pct
Sodium oleate + fuel oil	5 pct + 5 pct No. 4 fuel oil
Dresinate	5 pct
Dresinate + fuel oil	5 pct + 5 pct No. 4 fuel oil
$C_9H_{19}COONa$	1.25 mg per ml
$C_9F_{19}COONa$	0.625 mg per ml
$C_9F_{19}COOH$	1.25 mg per ml
$C_9F_{19}COOH$ in alcohol	25 mg per ml
$C_{11}F_{23}COONa$	0.125 mg per ml
CF_3CF_2 ⟨F⟩ —SO_3H*	1 pct
n-$C_8F_{17}SO_3H$	1 pct

* The symbol ⟨F⟩ is used to symbolize a completely fluorinated cyclic ring. The complete symbolic formula for this compound would be



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Discussion of this paper, TP 4143B, may be sent (2 copies) to AIME before Feb. 29, 1956. Manuscript, March 18, 1955. New York Meeting, February 1956.

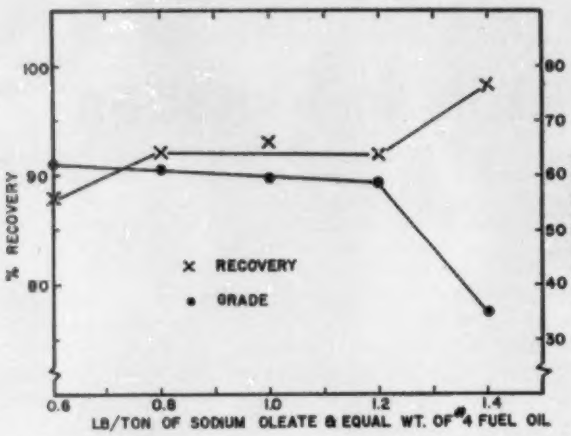


Fig. 1—Flotation of hematite from silica using oleate as the collector for hematite.

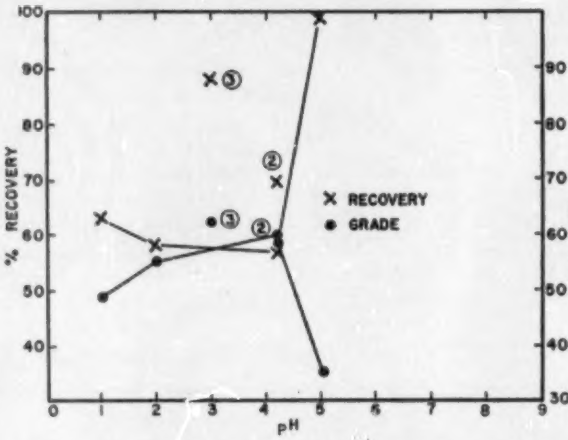
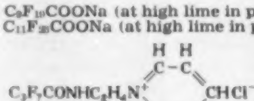
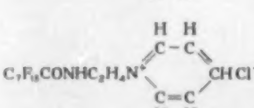


Fig. 2—Effect of pH on flotation of hematite from silica, using 1 lb per ton $C_9F_{19}COOH$ as the collector for hematite. Experiment No. 2 indicates successive additions of water solutions. Experiment No. 3 indicates smaller additions of water solutions.

Table II. Data on Fluorocarbon Reagents

Reagent Symbol	Composition	Concentration
	$C_9F_{19}COONa$ (at high lime in pulp) $C_{11}F_{23}COONa$ (at high lime in pulp)	0.625 mg per ml 0.125 mg per ml
F-11[10]		4.6 pct
F-6[10]		0.1 pct
F-7[10]	$C_7F_{15}CONHC_2H_4N^+(C_2H_5)_2CH_3I^-$	2.6 pct

Bé) with the 5 pct sodium oleate enhanced its ability to float hematite.

The results given in Fig. 1 establish the good performance of the flotation cell and also furnish a standard of comparison for other reagents.

Dresinate was used successfully by DeVaney[7] to collect hematite. When emulsified with an equal weight of 20° Bé fuel oil, it produced a good grade of concentrate but with lower recovery than reported by DeVaney. Table III compares the conventional collectors and gives the best results obtained in the pneumatic cell. One cleaner operation with no addition of reagents was used in the case of the sodium oleate systems. The final recovery and grades of the cleaner concentrates are given in Table III. Concentrates produced by Dresinate were not cleaned.

Table IV, which should be compared with Table III, shows the results obtained by using several different fluorochemicals and one hydrocarbon reagent. No frothers were used in these tests.

At high pH both the hydrocarbon and the fluorocarbon carboxylic acids gave stiff rubbery froths with no selectivity. At low pH the fluorocarbons gave poor froths which were well mineralized. No flotation was observed for the hydrocarbons. The perfluoro carboxylic acids gave *fleeting* mineralization, that is, when the froth was scraped or stirred, the mineral would drop into the pulp and would not float again until additional reagent was added. The values reported in Table IV for $C_9F_{19}COOH$ in water were the result of adding the reagent in increments of 0.1 lb per ton and quickly recovering the mineral before it could roll back into the pulp. A suitable frothing agent would probably have prevented this *fleeting* mineralization.

The values reported for Fig. 2 were obtained by removing as much of the mineralized froth as possible before the mineral dropped back into the pulp. Although the results are not as good as those obtained by incremental additions, they show that perfluoro carboxylic acid operates as a selective collector for hematite only below a pH of 4.

Effectiveness of fluorochemicals at a lower pH was anticipated on the basis of M. A. Cook's theory.[11] Prior observations of the effect of pH on the surface tension of solutions of the perfluoro carboxylic acids[2] showed that conversion to the acid form begins at pH 4.0 and adsorption at the air-liquid interface reaches a maximum at pH 1.0, see Fig. 3.

Since the perfluoro carboxylic acids are sparingly soluble in water the volume of reagent solution becomes impractical. Alcoholic solutions were tried because the acids are readily soluble in that medium. Frothing characteristics of the alcoholic solutions were inferior to those of the water solutions and this inferiority is reflected in the grades and recoveries. At low pH $C_{11}F_{23}COOH$ did not froth because of its low solubility. At the natural pH of the ore (5.7) a sparsely mineralized soap froth was obtained. No other tests were made on this reagent.

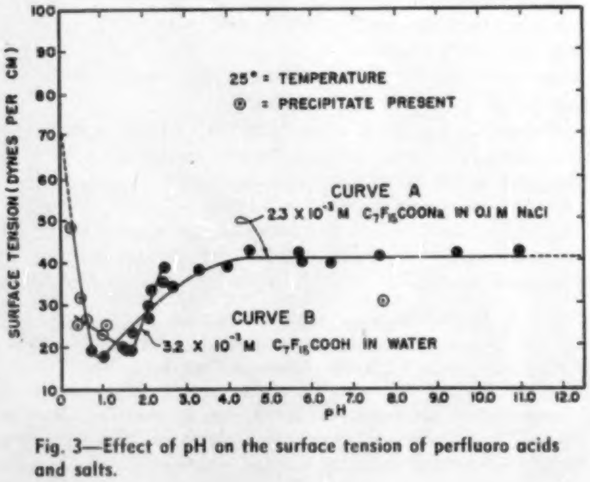


Fig. 3—Effect of pH on the surface tension of perfluoro acids and salts.

Table III. Conventional Collectors for Hematite

Reagent	Lb per Ton	pH	Recovery	Grade
Sodium oleate	1	>8	91.6	59.2
Sodium oleate + fuel oil	1	>8	96.0	60.0
Dresinate	1	9.2	no flotation	
Dresinate + fuel oil	1	8.2	39.7	62.1

Table IV. Experimental Collectors for Hematite

Reagent	Lb per Ton	pH	Recovery	Grade
$C_9H_{19}COONa$	1	4.1	19.0	56.4
$C_9F_{19}COOH$ in alcohol	1	2.0	58.1	55.3
$C_9F_{19}COONa$ in water	1	3.0	88.0	62.1
$C_{11}F_{23}COOH$ in alcohol and water	1	5.7	30.7	55.5
n-$C_8F_{17}SO_3H$	0.4	2.6	54.8	58.6
CF_3CF_2 (F) SO_3H	0.4	3.6	52.8	55.3

Although the fluorinated sulphonics did not give exceptional results in the few tests made, it should be noted that collection occurred at lower concentrations than with the fluorinated carboxylics. It is possible that depressants used in conjunction with the sulphonics could produce much better results at low reagent consumption.

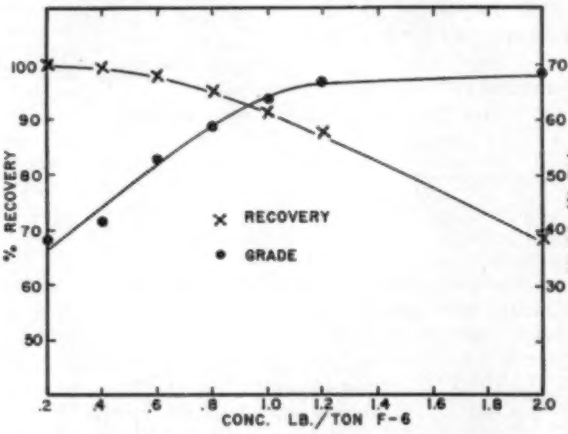


Fig. 4—Separation of hematite from silica using F-6 as the collector for silica.

In an endeavor to float activated silica the use of fluorinated carboxylics at a high lime concentration in the pulp, Table II, gave partial separations, but neither grade of concentrate nor recovery was considered satisfactory.

Outstanding separations were obtained by the use of fluorinated quaternary derivatives as collectors for silica. The shorter chained of the two used in these tests (F-11) was not a collector but was a frother compatible with F-6 when this compound was used as the collector. This would be expected according to Leja and Schulman.[12] Figs. 4 and 5 show the effects of reagent addition and pH on the flotation results. At a pH greater than 5 the optimum addition would be from 0.8 to 1.0 lb per ton. To reduce cell corrosion flotation would probably be conducted at a pH above 7.

The excellent collecting ability of F-6 was shown by the results of two tests. When 2 lb per ton of F-6 was used on the wash ore tailing, the grade of concentrate produced was 69.1 pct, which is within 1 pct of theoretical for Fe_2O_3, see Fig. 4. In a separate test, —100 mesh Montana quartz that had been

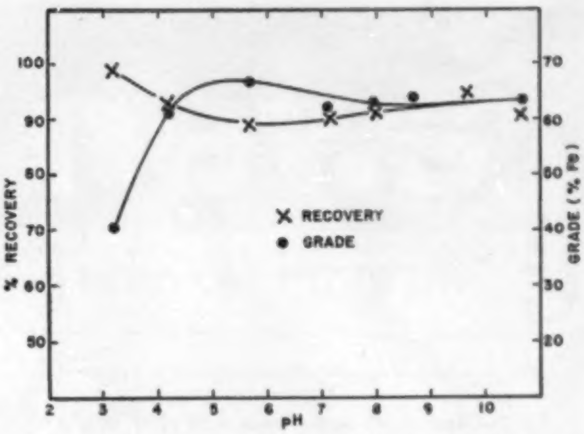


Fig. 5—Effect of pH on the separation of hematite from silica using F-6 as the collector for silica (1 lb per ton of F-6); pH regulated with H_2SO_4 or NaOH.

purified by thorough acid washing was completely floated, with 1 lb per ton of F-6 as the collector.

On a 27 pct iron feed which had not been deslimed or acid-scrubbed (normally a requirement for the flotation of iron ores) reagent F-6 showed unusual ability in producing a 52 pct iron concentrate at 74 pct recovery, even though this feed was more difficult to separate than the wash-ore tailings used in the preceding work. Retention of the slime fraction in the flotation feed would mean an increase of from 15 to 20 pct in the total iron recovery. More detailed studies are required using reagents of this type on whole ores.

In a single test a reagent, F-7, related to F-6 was also used. At 0.2 lb per ton, this reagent upgraded the ore—assaying 20 pct iron—to 56 pct iron at a recovery of 89 pct. The appearance of the froth indicated that less reagent could have been successfully used.

Separation of Sulphide Ores: Pyrite and quartz were chosen to represent the sulphide systems because they were readily available as high grade specimens. High grade pyrite and pure Montana quartz were crushed together in a roll mill to —20 mesh to form a master batch and wet-ground to —100 mesh in 5-min stages in a pebble mill. The ground ore was filtered, washed with deionized water, and put directly into a 250-g laboratory Mineral Separation cell with 750 ml of deionized water.

All adjustments of pH and any other modifying conditions were imposed upon the pulp before the

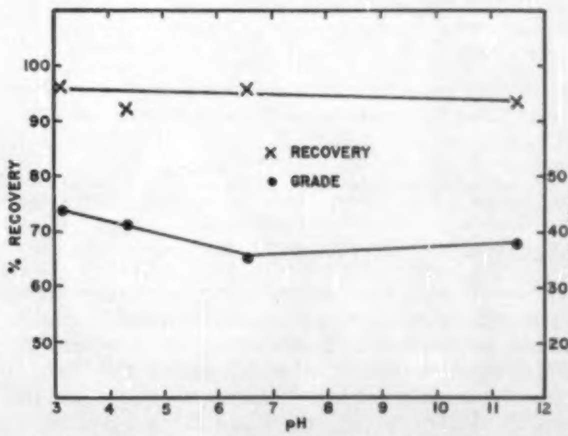


Fig. 6—Flotation of pyrite from silica (0.02 lb per ton of KEX); pH regulated with H_2SO_4 or NaOH.

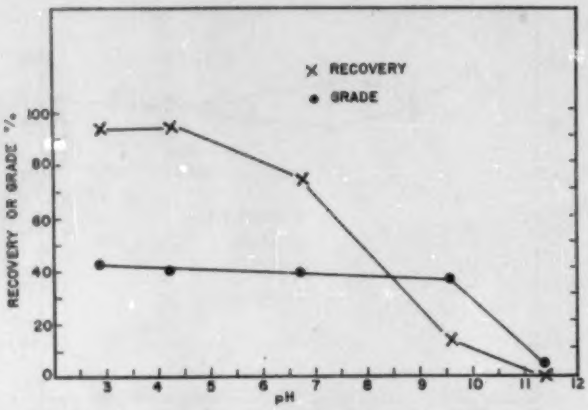


Fig. 7—Effect of pH on the flotation of pyrite from silica (0.02 lb per ton of KFEX); freshly prepared solutions.

collector was added to the cell. The collector was weighed in the dry state and dissolved immediately before being added to the pulp. After a 2-min conditioning time the frother was added, air was admitted to the cell, and flotation was completed to a barren froth. The solids were dried, weighed, and analyzed for iron.

Reagents for Sulphide Systems: The hydrocarbon potassium ethyl xanthate was made in the conventional manner.[13] The fluorinated ethyl xanthates (KFEX) and butyl xanthate (KFBX) were made in ether solution from the respective 1,1-dihydroperfluoro alcohols. All xanthates were kept at 0°C until used.

Fresh solutions of the fluorinated xanthates gave typical xanthate reactions whereas aged solutions showed the presence of decomposition products. Acid solutions of the perfluoroxanthates gave no precipitate with copper sulphate. Table V gives the analysis of the fluorinated xanthates.

The infrared absorption curves of the fluorinated xanthates did not indicate whether hydrocarbon xanthate was also present. Aqueous solutions of the fluorinated xanthates were basic, indicating an excess of KOH in the salts. This was confirmed by the infrared absorption curves.

Reagent grade sodium hydroxide and sulphuric acid were used to regulate the pH of the flotation pulps. Pine oil served as the frother for both hydrocarbon and fluorocarbon tests.

Pyrite was readily collected with potassium ethyl xanthate (KEX) additions of only 0.02 lb per ton at any pH from 3 to 11. Increasing the additions to 0.04 lb per ton increased neither the grade nor the recovery. Fig. 6 establishes the standard for the laboratory cell used in these tests.

Table V. Composition of Fluorinated Xanthates

Item	Sulphur		Potassium		Fluorine		Carbon	
	Calc.	Fnd.	Calc.	Fnd.	Calc.	Fnd.	Calc.	Fnd.
KFEX	29.0	24.5	18.2	20.3	26.6	23	16.8	14.7
KFBX	20.4	19.6	12.4	13.3	42.4	40	19.1	18.4

The fluorinated ethyl xanthate (KFEX) performed satisfactorily below a pH of 5 when the KFEX solution was freshly prepared, see Fig. 7. Aged solutions gave unsatisfactory results. At the natural pH for the pulp, 6.7, a fresh solution of KFEX resulted in a concentrate grade of 40 pct Fe with a recovery of 80 pct. Under the same conditions, a solution of KFEX ½ hr old gave an 18 pct grade at 22 pct recovery. Solutions older than this gave similar results.

Fluorinated butyl xanthate, KFBX, gave good results below a pH of 3 but was not as effective as KFEX. Since KFBX was less stable than KFEX, fresh solutions were always used.

It was generally observed with all the fluorinated xanthates that the froth was very slow to develop but was adequate once it had developed. The well-known incompatibility between fluorocarbon and hydrocarbon compounds could account for the poor frothing.

Contact Angle Measurements: Contact angle tests using fluorocarbon reagents were made on a number of polished mineral surfaces. In all cases the hysteresis was so great that reliable results could not be obtained. The trend of the results was toward development of larger values of the angle of contact in acid solutions.

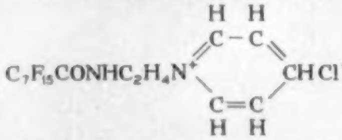
Conclusion

1) The C_9 and C_{11} perfluorocarboxylic acids are more effective collectors for hematite than their hydrocarbon analogues. Since the perfluoro oleic acid has not been prepared no direct comparison could be made for the oleates.

2) Since the perfluorocarboxylic acids are much stronger acids than the corresponding hydrocarbon acids, they must be used in more acid circuits than the ordinary fatty acids.

3) Perfluoro sulphonic acids are collectors of hematite at low reagent concentration.

4) The fluorinated quaternary compound



is a selective collector for quartz and gave excellent separation of quartz from hematite at pH of 5 or above, even on an iron ore which had not been deslimed. A related compound, $C_7F_{15}CONHC_2H_4N^+(C_2H_5)_2CH_3I^-$, is also a collector for quartz.

5) The fluorinated xanthates CF_3CH_2OCSSK and $CF_3CF_2CH_2OCSSK$ are selective collectors for pyrite only at low pH. They are less stable in aqueous solutions than the corresponding hydrocarbon xanthates.

References

[1] H. M. Scholberg, R. A. Guenthner, and R. I. Coon: Surface Chemistry of Fluorocarbons and Their Derivatives. *Journal of Physical Chemistry*, 1953, vol. 57, p. 923.

[2] E. L. Talbot: *The Effect of pH and Ionic Strength Upon the Surface Tension of Certain Perfluoro Carboxylic Acids.* Presented before the 124th Meeting of the American Chemical Society, September 1953.

[3] A. H. Ellison, H. W. Fox, and W. A. Zisman: Wetting of Fluorinated Solids by Hydrogen-Bonding Liquids. *Journal of Physical and Colloid Chemistry*, 1953, vol. 57, p. 672.

[4] E. F. Hare, E. G. Shafrin, and W. A. Zisman: Properties of Films of Adsorbed Fluorinated Acids. *Journal of Physical Chemistry*, 1954, vol. 58, p. 236.

[5] J. H. Simons: U. S. Patent 2,519,983 (1950) to Minnesota Mining & Mfg. Co.

[6] N. C. Christensen: Process of Concentrating Oxidized Ores and Minerals. U. S. Patent 1,467,354 (1923).

[7] F. D. DeVaney: Froth Flotation of Oxide Iron Ore. U. S. Patent 2,470,150 (1946).

[8] E. C. Herkenhoff: Flotation of Iron Ores. U. S. Patent 2,387,081 (1945).

[9] C. S. Chang, S. R. B. Cooke, and R. O. Huch: Starches and Starch Products as Depressants in Amine Flotation of Iron Ores. *AIME Trans.*, 1953, vol. 196.

[10] A. H. Ahlbrecht and G. B. Blake: Quaternary Ammonium Compounds from Fluorinated Acids. Presented before the 126th Meeting of the American Chemical Society, September 1954.

[11] M. A. Cook and J. C. Nixon: Theory of Water-Repellent Films on Solids Formed by Adsorption From Aqueous Solution of Heteropolar Compounds. *Journal of Physical and Colloid Chemistry*, 1950, vol. 54, p. 445.

[12] J. Leja and J. H. Schulman: Flotation Theory: Molecular Interaction Between Frothers and Collectors at Solid-Liquid-Air-Interfaces. *AIME Trans.* 1954, p. 221.

[13] L. S. Foster: The Preparation of Xanthates and Organic Thiocarbamates. Utah Engineering Experiment Station TP 5, 1929.

aime news

1956 Annual Meeting Technical Program

As the dates for the 1956 Annual Meeting—February 20 to February 23—draw close Program Committees are checking the last details of the Mining Branch program. Mining sessions will be held in the Statler Hotel. *The program given is as of Nov. 15, 1955.*

Bermuda Cruise

Queen of Bermuda. **February 24 to March 3**

Discussion on mining, metals and oil, plus a real opportunity for rest, relaxation and a good get-together with friends is offered by the Bermuda cruise, climax of the Annual Meeting.

The luxurious *Queen of Bermuda* leaves New York at 5 pm on February 24, and arrives in Bermuda the morning of February 26. After two days in Bermuda the cruise goes to Nassau, and then returns to New York on March 3. For full information write Leon V. Arnold, 33 Washington Square West, New York 11, N. Y.

Requests for space must be made by December 27! !

Coal

The Coal Div. will start its program with a session on Mining Methods and Problems which will include: *Anthracite Mine Water Problem*, by D. H. Connelly and R. A. Lambert; *A Report on Industrial Engineering*, by R. L. Frantz; and *Applying Industrial Engineering Techniques for Lowering Coal Mining Costs*, by W. L. Zeller.

Several papers scheduled for the Continuous Mining Progress Reports Forum are: *Case History of a Goodman Coal Boring Machine*, by S. Krickovic; *Case History of a Jeffrey Colmol Mining Machine*, by J. N. Crichton; and *Case History of a Joy CM-1 Mining Machine*, by W. B. Jamison.

The Preparation Committee of the AIME Coal Div. has arranged a one-day symposium on Planning a Coal Preparation Plant. The symposium will occupy morning and afternoon sessions, Tuesday, February 21. The subject was selected as that best suited for the Preparation Committee's assignment under Chairman Yancey's overall plan of having the Division best serve the coal industry.

There are many factors to be considered in planning a coal preparation plant but one of the most important is the selection of the proper equipment. It is this phase of the planning program that will be covered in the symposium, from both theoretical and practical viewpoints. The lead-off paper is on the overall economics of coal preparation plants and the influence of market demands on the preparation of coal.

Papers to be presented during the Symposium, Planning a Coal Preparation Plant, are as follows: *Influence of Market Demands on Coal Preparation*, by J. B. Morrow; *The Selection of Types of Cleaning Units for a Coal Preparation Plant*, by W. M. Berthoff. This session will also contain: *Formal Discussion on Jigs*, by A. P. Massmann; *Formal Discussion on Dense Medium Cleaning*, by S. A. Miller; *Formal Discussion on Wet Tables and Fine Coal Rheos*, by J. Griffen; and *Formal Discussion on Dry Tables*, by W. G. McCulloch.

This symposium will be continued in the afternoon with the following papers: *The Selection of Dewatering and Drying Equipment*, by G. H. Kennedy and J. L. Walker, Jr.; *Formal Discussion on Dewatering Screens*, by D. R. Mitchell; *Formal Discussion on Centrifuges*, by W. L. McMorris; *Formal Discussion on Thermal Driers*, by E. R. McMillan; *The Selection of Water Clarification Equipment*, by J. M. Vonfeld; and *The Influence of Quality of Circulation Water on Plant Performance*, by T. M. Larimer.

The Materials Handling Symposium will include such papers as: *From Working Face to Portal*, by A. R. Anderson, M. Cunningham, and W. Hanson; *From Portal Through Preparation Plant to RR Cars, Barges and Trucks*, by E. H. Citron and R. L. Llewellyn; *From Mine to Consumer*, by J. T. Crawford and A. W. Holmes; and *Research in Selecting Conveyor Idler Rolls*, by Felix du Breuil.

A session on Utilization—Carbonization will feature: *Better Coke by the Thermal Treatment of Coal*, by F. W. Smith, D. A. Reynolds, and G. W. Birge; *Structural Changes of Heated Coals*, by M. O. Holowaty; and *Coal to Coke Sulphur Rejection Studies, A Comparison of Data Obtained From Various Test Ovens*, by E. C. Knapp, G. L. Barthauer, R. J. Grace, and T. S. Spicer.

The list of papers to be presented during the Utilization—Gasification session are: *The Petrographic Composition of Two Alabama Whole Coals Compared to the Size and Density Fractions*, by Reynold Q. Shotts; *Recycling Unburned Residue in an Entrainment-type Gasifier*, by J. Jonakin, W. C. Harrold, C. R. McCann, and J. W. Myers; and *Hydrocarbonization of Coal*, by A. P. Pipilen, R. W. Hiteshue, W. Kawa, and W. A. Budd.

The General Technical session will deal with: *Some Aspects of Permanent Support of Overburden on Coal Beds*, by C. T. Holland and F. L. Gaddy; *Effects of Developments in Iron Ore Supplies and Metallurgy on Fuel Requirements*, by H. Perry, J. DeCarlo, and E. P. Carman; and *Use of Surface Active Agents in the Filtration of Coals*, by S. C. Sun and H. G. Papacharalambous.

Mining

The Mining Subdivision has scheduled the following session topics for the Annual Meeting: Latin American session, Uranium Mining Symposium, Symposium on Canadian Mining Practice, and two general mining sessions.

J. G. Hall, Chairman of the general mining session reports the following schedule: Pre-session movie, *Titanium, the 9th Element; Modern*

Hydraulic Mining in Florida, by C. V. O. Hughes; *More Rock per Dollar from MacIntyre Pit*, by F. R. Jones; *Mining and Milling Cobalt Ore is No Cinch*, by E. B. Douglas; and *Cold Bent Steel Mine Supports*, by R. S. Siegrist.

Charles Huston, Chairman of the Canadian Mining Practice Symposium reports the following papers are among those to be presented: *Sherritt Gordon's Nickel-Copper Mines* by Alan E. Gallie; *Mining at United Keno Hill Mines Ltd.*, by R. L. Segsworth and A. E. Pike.

S. T. Delicate will present: *Homestake Mines Utah Uranium* in the session on Uranium Mining. Other papers to be included in this session will be listed in the complete program in the January issue.

Roger V. Pierce, general chairman for the mining program reports the session chairman and authors are working hard on the complete program. The final listing will also be in the January issue.

Geology

The Geology Subdivision now plans to hold five joint sessions with the Society of Economic Geologists. One of these sessions will be a joint session with the AIME Industrial Minerals Div. on Geology of Industrial Minerals. Papers to be included in this triple session are: *Economic Geology of the Phosphate Deposits of Florida*, by J. B. Cathcart; *Fluorspar Deposits in Coahuila, Mexico*, by W. N. McAnulty; *Economic Geology of Salem Limestone in the Indiana Building Stone District*, by J. B. Patton; and *Geology and Selective Mining of the Gabbs Magnesite Deposits, Gabbs, Nev.*, by H. P. Willard and C. Martin.

Four other meetings to be jointly sponsored with SEG are: A session on ore deposits, Symposium on Natural Concentration of Rare Metals, Symposium on Primary Shallow Depth Deposits, and Symposium on Primary Ore Solutions. Among the papers to be presented at these sessions are: *Mineralizing Solutions That Carry and Deposit Iron and Sulphur*, by B. S. Butler; *Structural Control of Uranium Deposits in the Zuni-Mt. Taylor Region, New Mexico*, by J. W. Gabelman; *Economic Geology of the Yttrium-Group Elements*, by E. William Heinrich; and *Deuteric Alteration and its Possible Significance to Wallrock Alteration in Some Rocks of the Boulder Batholith, Montana*, by G. J. Neuerburg.

Geophysics

Ralph C. Holmer, Program Chairman of the Geophysics Subdivision, announces that 21 papers have been submitted. These will be grouped in four or five sessions under such subjects as: Aerial Exploration Methods, Geochemical Prospecting, and Applied Geophysics in the Search for Ore Deposits.

Among the papers to be presented in the Aerial Exploration Methods session are: *A Reconnaissance-Detail Program for Aeromagnetic Search*, by F. Woods Hinrichs; *Application and Interpretation of Airborne Electromagnetic Surveys in Canada*, by H. S. Scott and D. G. MacKay; *Airborne Gamma Ray Spectrometer Surveys*, by Hans Lundberg; *The Airborne Adaptation of the Nuclear Magnetic Resonance Magnetometer*, by Martin E. Packard; and *Airborne Magnetometer Profile from Olympia, Washington to Laramie, Wyoming*, by W. B. Agocs and R. R. Hartman.

The Geochemical session features: *Heavy Metals in Stream Sediment as an Exploration Guide*, by H. E. Hawkes and Harold Bloom; *Soils in Geochemical Prospecting*, by H. V. Warren and R. E. Delavault; and *Rubeanic Acid Copper Test as an Aid to Leached Outcrop Interpretation*, by G. L. Sawyer.

Papers in the session on Applied Geophysics in the Search for Ore Deposits include: *Ages of Some Canadian Ore Deposits and Their Relation to Structure of the Precambrian Shield*, by J. T. Wilson; and *Gamma-Ray Logging in the Search for Uranium*, by D. F. Coolbaugh.

Among the other papers listed on the program are: *Multiple Scattering of Gamma Rays from a Buried Point Source*, by Robert J. Uffen and W. B. Muir; *A Gravity Anomaly Simulator*, by Gerrard, Geyer, Reynolds, and Romberg; and *The Use of Electrical Transients to Measure the Static Dielectric Constant of Rocks*, by George V. Keller.

Minerals Beneficiation

Papers scheduled for the Monday session on Concentration are: *Streaming Potential Studies on Quartz Flotation with Cationic Collectors*, by A. M. Gaudin and D. W. Fuerstenau; and *Flotation of Primary Uranium Minerals*, by Burt C. Mariacher; *Fluorochemical Collectors in Flotation*, by S. R. B. Cooke and E. L. Talbot; and *Flotation of Rutile, Ilmenite, and Cassiterite*, by C. C. deWitt and K. U. Patel.

The Material Handling and Operating Control session will feature: *Reagent Control in Flotation*, by C. H. G. Bushell and M. Malnarich; *Instrumentation in Milling Mesabi Iron Ores*, by R. Cahill; *Tailing Disposal at Morenci*, by J. E. Papin; and *Conveyor Transfer Point Redesign Using High Speed Photography*, by D. J. Reed, Jr.

The papers on Air Separation-Milling of Nonmetallic Ores to be presented in a joint session with the Ind. Min. Div. are listed under that division.

The Concentration session on Tuesday will deal with *Improved Contact Angle Apparatus for Flotation Research*, by Donald W. McGlashan and K. N. McLeod; *Operation of a Humphreys Spiral Plant*, by Henry D. Spedden; *Flotation of Uranium Minerals*, by John N. Butler; and *Pegmatite Flotation*, by Robert E. Baarson and John Parks.

The joint session with the Extractive Metallurgy Div. on Hydrometallurgy—Solution and Precipitation will present: *Treatment of Low-Grade Scheelite Ores*, by F. W. Wessel; *New Leaching in Place at Cananea*, by R. C. Weed; *The Effect of Impeller Location in the Suspension of Solids*, by Norman Parker, J. Crowl, J. G. Papalias, and J. R. Spraul; and *Copper Leaching and Precipitation at Anaconda's Weed Heights Plant*, by A. E. Miller.

The papers included in the Mill Design session are: *Economic Determination of a Contemplated Mining and Milling Project*, by James Boyd; *Interpretation of Research and Ore Test Data*, by D. E. Newton and H. J. Gisler; *Crushing Plants*, by F. E. Briber, Jr.; and *The Owner, the Engineer, the Contractor*, by J. D. Grothe.

The Concentration session on Wednesday morning will review: *Laboratory Recovery of an Oxidized Lead Mineral from a Southeast Missouri Deposit*, by M. M. Fine and E. J. Haug; *Ionic Size in Flotation Collection of Alkali Halides*, by D. W. Fuerstenau and M. C. Fuerstenau; *The White Pine Concentrator*, by W. A. Hamilton and Virgil Lessels; and *Adsorption of Ethyl Xanthate on Pyrite*, by A. M. Gaudin, P. L. deBruyn, and Olav Mellgren.

The Crushing and Grinding session will feature a paper on the Aerofall mill at Benson Mines; *Predicting Size Distribution in Classifier Products*, by E. J. Roberts and E. B. Fitch; *Gyratory Ball Mill*, by A. W. Fahrenwald; and *Allis-Chalmers Vibrating Grinding Mill*, by F. E. Briber, Jr.

The symposium, Starting a New Mill, will cover the following subjects: *Organization Prior to Startup*, by W. A. Hamilton, E. W. Lindroos, and C. E. Osborn; *Actual Startup*, by H. L. McNeill and H. R. Hendricks; and *Initial Operations*, by R. H. Lowe and W. A. Arpi.

A second Crushing and Grinding session on Thursday includes: *Grinding Practice at Chuquicamata*, by D. S. Sanders; *Energy Transfer by Impact*, by R. J. Charles and P. J. deBruyn; *Effect of Heat Treatment and Magnetic Conversion on Grindability of Non-Magnetic Taconites*, by R. A. Person and Will Mitchell, Jr.; and *Correlation of Rod Mill Capacities with Operating Variables*, by Nathaniel Arbiter.

Some of the papers to be presented at the Solids-Fluids Separation, Pyrolysis session are: *Natural and Synthetic Polyelectrolytes as Flocculants for Mineral Suspensions*, by M. E. Wadsworth and I. B. Cutler; *The Rotobelt Filter—A New Concept*, by B. A. Schepman, C. F. Cornell, and D. A. Dahlstrom; and *Fluosolids Installation at Bethlehem's Sparrows Point Plant*, by J. K. Kurtz and Harold Scharf.

(Continued on page 1160)

Industrial Minerals Div. Gets Together At Charlotte, N. C.

Fair Weather — Interesting Sessions — All-day Field Trip — Highlight Three-Day Fall Meeting

Informative and informal are typically the key words in describing an Industrial Minerals meeting —and the fall meeting of the Division, held this year at Charlotte, N. C., was no exception. The meeting, October 27 to 29, included two days of technical sessions and an all-day field trip on Saturday. Meeting attendance was over 100 and about 55 took in the plant and mine visits.

Thursday morning was taken up with registration and the Ind. Min. Div. held an Executive Committee meeting. G. W. Josephson was Chairman of the technical session that afternoon. The leadoff paper by Byron Cooper set the scene with a discussion of Appalachian geology and mineral deposits. A paper by H. E. LeGrand discussed ground water occurrence in the igneous and metamorphic rocks of the southern Appalachians. A film and paper on blasting research by W. I. Duvall stimulated considerable discussion among the operations-minded members attending. Apparently blasting —like grinding, and crushing—is one of those basic operations that loom high in importance on the cost sheet and arouse no end of interest and discussion.

Friday morning session was taken up with a symposium on industrial minerals that covered mica, barite, kyanite, and titanium minerals. Among those contributing were Chairman R. M. Grogan, and speakers Ralph Adair, L. G. Wilson, S. J. Beers, and R. M. Lewis.

The ladies attended the first item of the afternoon session, a movie presented by National Lead Co., *Titanium—From Ore to Metal*. Other papers that afternoon were by J. Walton on kaolin production and by E. R. Goter on pegmatite mining operations.

Social Events

Hit of the meeting was the Thursday dinner speaker James Mair of Chicago Bridge & Iron Co. Mr. Mair led into his topic, "Business Practice for the Engineer," with a witty series of definitions of experts, engineers, salesmen, and purchasing agents, before giving his listeners an idea of the pitfalls faced by engineers when they buy, specify, or sell processing equipment.

On Friday evening a cocktail hour preceded the informal dinner and dance. Entertainment was of the do-it-yourself variety under the skillful guidance of Art Hall. Art is fast establishing a tradition for this sort of entertainment, having deftly handled the details last year at Lake Placid.

Oscar M. Wicken (left), General Chairman of the meeting, congratulating James Mair, the speaker at Thursday night's dinner. Mr. Mair's topic was "Business Practice for the Engineer."

Field Trip

Early Saturday morning an automobile cavalcade took the 55 attending the field trips on a round of the nearby industrial minerals producers. First stop was at Commercialores Inc. kyanite property at Henry Knob, near Clover, S. C. Here the party was briefed by S. J. Beers and Tom Kesler before climbing to the hill-top quarry. A variety of minerals attracted attention from the geologists, while the sweeping view provided reason enough for the climb for the rest of the party.

From Henry Knob the group swung back into North Carolina, stopped for lunch, and then went to the Foote Mineral Co. spodumene-pegmatite operation at Kings Mountain. Here the group toured the neat and active pit operation. Final stop on the tour was at the mica mine and mill of Kings Mountain Mica Co. where decomposed granite is treated in two mills to produce final mica products. Tom Kesler helped supply the technical details for the group and kept it on the route.

A word of thanks from the entire party went to Oscar Wicken, who headed the job of organizing and directing the meeting. Mr. Wicken should probably take credit for the weather, which held warm and mild—*R.A.B.*

Field trip making its first stop on Saturday at the open pit, Commercialores Inc., kyanite property, Henry Knob, Clover, S. C. The open pit is located near the top of an isolated hill.

AIME-ASME Columbus Meeting Inaugurates Several Features

One hundred and ninety attended the 18th Annual Joint Solid Fuels Conference of the Coal Div., AIME, and the Fuels Div., American Society of Mechanical Engineers at the Neil House, Columbus, Ohio, October 19 to 20, a meeting that was in reality a two-day session with a late recess for sleep the first night. An attentive, interested crowd of solid fuel engineers and technologists blew in early Wednesday morning and stuck together through the four technical sessions, two coffee breaks, two luncheons, a cocktail party, and a banquet. True, a few did stay over to Friday, October 21, for visits to Battelle Memorial Institute, Bituminous Coal Research Inc., and several local plants.

Several innovations made this conference notable. There was an authors' and presiding officers' breakfact each morning. At these very businesslike affairs, authors and chairmen got acquainted, and arrangements for the technical sessions were pointed up. A bit of ritual was Joe Clark's presentation of the gavels to chairmen for the day. The coffee break immediately following the first paper at the morning sessions was the second conference innovation. Any apprehension that the audience would get lost was needless. The coffee was hastily gulped and all hands filed back. The shot of caffeine, plus fresh air, had a bracing effect that carried through to luncheon. Another feature of this conference was that the registrants' envelopes contained something to represent every paper on the program, either the entire paper or a sizable abstract.

At the initial luncheon on Wednesday David R. Mitchell, Division Secretary, told the combined AIME-ASME group what the AIME Coal Div. is and what it does and Carroll F. Hardy, Chairman, Fuels Div. ASME, took an oral, informative "look" at his Division.

An enjoyable feature of the banquet, Wednesday evening, was the song fest by the Ohio State University Men's Glee Club. L. C. Campbell, president, National Coal Assn., was the speaker; his subject, "Coal—Our National Heritage." Here are a few enlightening statistical facts from his address: "Coal supplies 65.6 pct of the fuel used in generating the nation's electricity, exclusive of water power . . . . Coal heats one third of the houses of America, supplies the essential raw materials for nearly a third of the entire U. S. organic chemical industry . . . . The industry will need increasing numbers of engineers in almost all phases of its work in the years immediately ahead . . . . The industry has established 99 scholarships . . . . available in nine states, to help deserving coal mining engineer candidates."

Prof. W. A. Mueller, Ohio State University, represented AIME President H. DeWitt Smith at the banquet head table; Thompson Chandler, vice president ASME, represented ASME President David W. R. Morgan.

At the Percy Nicholls luncheon meeting on Thursday E. R. Price, chairman of the Award Committee, introduced Elmer Kaiser, who in turn presented the Percy Nicholls Award for 1955 to Ralph M. Hardgrove. The award is for notable scientific or industrial achievement in the field of solid fuels. Although the citation is too long for present space, the last paragraph indicates the whole: "In him we recognize an internationally known Engineer, Research Consultant, Author, and Inventor whose important work in the field of solid fuels has contributed materially to the advancement of steam-generating plants." Ralph A. Sherman, discoursing on "A Man and His Work," told the members much about Percy Nicholls, his life, personality and work, all of which was very interesting. He exhibited a large photograph of Nicholls taken in his laboratory.

For the technical papers one must look to the respective media of the two divisions. There were seven of AIME origin and five ASME. The discussion was earnest and extensive. Two papers—referred to as long hair—were washed out of the hair of so many speakers from the floor that the discussion period had to be extended. The papers are listed by sessions, on page 878 of the September MINING ENGINEERING.

This Joint Solid Fuels Conference, generally acclaimed as highly successful, was engineered by a committee so distinctly on the job that its members richly deserve individual mention, as follows:

Elmer R. Kaiser, general chairman, AIME; William T. Reid, co-chairman, ASME; J. H. Melvin—treasurer; finance—John F. Fulford; hotel—M. L. Smith, E. B. Lund, and Paul Bucher; registration—C. J. Lyons, S. D. Heil, and J. D. Hummell; publicity—A. B. Clymer; technical details—W. C. Holton; printing and signs—G. E. Haney, W. L. Hartman, and J. R. Lucas; entertainment—J. M. Pilcher, J. F. Cunningham, Jr., and J. A. Eibling; plant trips—J. R. Garvey, R. J. Anderson, and P. O. Kock.

The program chairman for AIME was T. R. Jolley; for ASME, C. H. Marks.

H. F. Yancey is the chairman of the Coal Div. AIME and Carroll F. Hardy is chairman of the Fuels Div. ASME.

The chairman of the Ladies' Activities Committee was Mrs. Hazel G. Reid. Twenty-seven ladies attended the Conference.

The 19th Annual Joint Solid Fuels Conference will be held next year at the Sheraton-Park Hotel, Washington, D. C., on either Wednesday and Thursday or Thursday and Friday in the week of October 22. The co-chairmen of the General Committee for the Conference are L. R. Caplan, ASME, and L. C. McCabe, AIME.—*E.J.K., Jr.*

L. C. Campbell, President, National Coal Assn., was the speaker at the banquet, October 19. His topic was "Coal—Our National Heritage."

Left, Ralph M. Hardgrove, 1955 Percy Nicholls Award Recipient, and Elmer R. Kaiser, General Chairman of the Conference.

1956 Publications Policies Established

Pursuant to Article X of the bylaws of the AIME, the following information is hereby given as to the "conditions, prices, and terms under which the various classes of members, and Student Associates, severally, shall be privileged to obtain publications of the Institute during the ensuing year."

Publications authorized for issue in 1956 include the following: MINING ENGINEERING, published monthly, containing material, including technical papers, of interest to those engaged in exploration, mining geology and geophysics; metal, nonmetallic, and coal mining and beneficiation; and fuel technology. The JOURNAL OF METALS, published monthly, containing material, including technical papers, of interest to those engaged in nonferrous smelting and refining, iron and steel production, and physical metallurgy. The JOURNAL OF PETROLEUM TECHNOLOGY, published monthly in Dallas, containing material, including technical papers, of interest to those engaged in petroleum and natural gas drilling and production.

Annual subscriptions to any one of the above journals will be provided all members in good standing without further charge, a subscription credit of $6 for members and $4 for Student Associates being included in the dues paid. (A member ceases to be in good standing if current dues are not paid by April 1). If more than one of the monthly journals is requested, $4 extra will be charged for an annual subscription, or 75¢ for single copies of regular issues and $1.50 for special issues. The nonmember subscription price for each journal is $8 in the Americas and U. S. possessions; foreign, $10; for single issues 75¢ in the Americas; $1.00 foreign for regular issues; $1.50 for special issues. Student Associates will be entitled to the same privileges for all publications as members. AIME members subscribing to more than one of each of the three monthly journals will be billed at the nonmember rate of $8 per year, domestic; $10 foreign, for the extra subscription(s).

Three volumes of *"Transactions"* are authorized for 1956 publication, as follows: No. 202, Mining Branch; No. 203, Metals Branch; and No. 204, Petroleum Branch. Volumes 202 and 204 will be available to members at $3.50 each for a first copy if paid for in advance with dues; otherwise at the nonmember rate of $7 less 30 pct. Nonmembers $7 in the United States; foreign $7.50. Volume 203 will be available to members at $4.50 each for a first copy if paid for in advance with dues; otherwise at the nonmember rate of $9 less 30 pct. Nonmembers $9 in the United States, foreign $9.75.

R. A. BEALS

S. TUCKER

AIME Editorial Staff Changes Made

E. O. Kirkendall, Secretary of the Institute, has announced that Rixford A. Beals has been appointed Editorial Director of both MINING ENGINEERING and the JOURNAL OF METALS. He was Associate Editor of MINING ENGINEERING.

Mr. Beals, who is a graduate of the University of California in process metallurgy, served three years in the Army Air Force, and spent a year at a cyanide plant in Sinaloa, Mexico. Prior to joining the staff of MINING ENGINEERING in 1952 he had spent two years as research engineer on ore beneficiation in the laboratory of Jones & Laughlin Steel Corp., Negaunee, Mich.

At the same time as the above change was announced, Stan Tucker was named Advertising Director for both MINING ENGINEERING and JOURNAL OF METALS. Mr. Tucker, a 1926 Yale University graduate in electrical engineering, has had many years of both editorial and publishing experience. He is publications manager for the American Society of Mechanical Engineers and will continue this affiliation.

Alvin S. Cohan, AIME Manager of Publications, has resigned to accept a position with Titanium Metals Corp. of America.

Special volumes now planned for publication in 1956 include the following: *Open Hearth Proceedings*, Vol. 39, price to AIME members $7; nonmembers, $10. *Blast Furnace, Coke Oven, and Raw Materials Proceedings*, Vol. 15, AIME members $7; nonmembers $10. *Electric Furnace Steel Proceedings*, Vol. 13, AIME members $7; nonmembers $10. *Statistics of Oil and Gas Development and Production*, Vol. 9, covering data for the year 1954, members $5, nonmembers $10. Proceedings of Niagara Falls Conference on Reactive Metals tentative; price to be determined.

If dues are paid subsequent to January 31, back issues of Institute publications will be supplied only if adequate stocks are on hand. A member is not entitled to receive a volume of *"Transactions,"* or a special volume, in lieu of a monthly journal, free of charge on membership. Members in arrears for dues are not entitled to special members' prices for publications.

Rocky Mountain Members may have their choice of an annual subscription to one of the monthly journals on request.

Dues Bills In Mail

Pursuant to Article II, Section 2, of the bylaws of the AIME, notice is hereby given that dues for the year 1956 are payable Jan. 1, 1956, as follows: Members and Associate Members, $20; Junior Members for the first six years of Junior Membership, $12, and thereafter, $17; Student Associates (including an annual subscription to a monthly journal), $4.50.

Dues bills were mailed during the middle of November. Prompt payment will assure uninterrupted receipt of the publications desired in 1956. If, for any reason, a bill is not received within a reasonable time, headquarters should be notified.

Institute Names 1956 Legion of Honor

Each year at the Annual Banquet in February, those members of the AIME who have continuously maintained their membership for 50 years are given special recognition. They are seated at the head table as guests of the Institute and are added to the membership of the Legion of Honor. The names of those who will achieve this status in 1956 are as follows:

Caine, Milton A.
New York, N. Y.
Case, Albert H.
Charlottesville, Va.
Ferguson, Henry G.
Washington, D. C.
Graham, Stanley N.
Kingston, Ont., Canada
Graton, L. C.
Orange, Conn.
Lewis, Robert S.
Oakland, Calif.
Schrader, Erich J.
Reno, Nev.
Snelling, Walter O.
Allentown, Pa.
Thorn, J. F.
Millendon, W. Australia
Turner, Scott
New York, N. Y.

Nominating Committee For AIME Officers, 1957

The following have been named by the Council of Section Delegates, the Branch Councils, and the President of the Institute to constitute the Nominating Committee for AIME Officers in 1957. The Committee will meet during the Annual Meeting of the Institute in Chicago, Feb. 20 to 23, 1956 and select the official slate. If the principal finds it impossible to attend, the alternate will act in his place; otherwise, the alternate will not be present at the meeting of the Committee. The names of the alternates are given in parentheses.

Appointment of President, with approval of Board of Directors: John S. Bell, Chairman, Humble Oil & Refining Co., 612 S. Flower St., Los Angeles, Calif. (Frank A. Ayer, 21 E. 40th St., New York, N. Y.); Hugo E. Johnson, Lake Superior Iron Ore Assn., 1400 Hanna Bldg., Cleveland, Ohio (John J. Golden, U. S. Steel Corp., 525 Wm. Penn Place Bldg., Pittsburgh); John Lokken, Dow Chemical Co., Box 351, Pittsburg, Calif. (W. W. Everett, Glen Alden Coal Co., 16 S. River St., Wilkes-Barre, Pa.)

Executive Committee, Council of Section Delegates: Clark Wilson, New Park Mining Co., 904 Walker Bank Bldg., Salt Lake City, Utah. (Lamar Weaver, Tennessee Copper Co., Copperhill, Tenn.)

Mining Branch Council: J. K. Richardson, Kennecott Copper Corp., Hurley, N. M. (S. D. Michaelson, Kennecott Copper Corp., 1515 Mineral Sq., Salt Lake City, Utah.) M. D. Cooper, National Coal Assn., 5430 Aylesboro Ave., Pittsburgh 17, Pa. (J. D. Forrester, College of Mines, Univ. of Idaho, Moscow, Idaho)

Metals Branch Council: Frank T. Sisco, Engineering Foundation, 29 W. 39 St., New York, N. Y. (T. D. Jones, American Smelting & Refining Co., Perth Amboy, N. J.)

Petroleum Branch Council: John R. McMillan, Monterey Oil Co., 430 Statler Bldg., 900 Wilshire Blvd., Los Angeles, Calif. (Claude R. Hocott, Humble Oil & Refining Co., 1200 Main St., Houston, Texas)

District 1: J. K. Reynolds, Halliburton Oil Co., 250 Park Ave., New York, N. Y. (Fred Briggs, Jr., California Texas Oil Co. Ltd., 380 Madison Ave., New York, N. Y.

District 2: R. J. G. Fleck, Jones & Laughlin Ore Co., Star Lake, N. Y. (Malcolm Lowry, St. Joseph Lead Co., Balmat, N. Y.)

District 3: S. S. Clarke, 429 Cherokee Ave., Baxter Springs, Kan. (O. A. Rockwell, Eagle-Picher Co., Miami, Okla.)

District 4: Theron Reed, Owens-Corning Fiberglas Corp., Newark, Ohio. (Richard Lund, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio)

District 5: R. D. Satterley, Inland Steel Co., Ishpeming, Mich. (James Westwater, Cleveland-Cliffs Iron Co., Ishpeming, Mich.)

District 6: Lincoln F. Elkins, Sohio Petroleum Co., 1300 Skirvin Tower, Oklahoma City, Okla. (H. D. Christner, Continental Oil Co., P. O. Box 795, Oklahoma City, Okla.)

District 7: D. H. Beetem, Aluminum Co. of America, P.O. Box 120, Vancouver, Wash. (Clifford J. Hicks, The Anaconda Co., 526 Hennessy Bldg., Butte, Montana)

District 8: T. G. Chapman, College of Mines, Univ. of Arizona, Tucson, Ariz. (P. D. I. Honeyman, Inspiration Consolidated Copper Co., Inspiration, Ariz.)

District 9: D. E. Hewitt, Box 472, Brownfield, Texas (Gus Athanas, Box 268, Lubbock, Texas)

District 10: V. C. Perini, Jr., Box 840, Abilene, Texas. (Joseph B. Jenkins, Stanolind Oil & Gas Co., Box 120, Abilene, Texas)

Announce 1956 Honors

The following honors will be conferred at the annual banquet on Feb. 22, 1956 at the Waldorf-Astoria, New York:

Charles F. Rand Gold Medal to **Henry DeWitt Smith,** "For distinguished achievement and inspired leadership in the administration of all phases of the Mining Industry at home and abroad, in peace and in war, throughout a long and distinguished career."

James Douglas Gold Medal to **Charles R. Kuzell,** "For outstanding contributions to nonferrous metallurgy, particularly in the field of copper smelting; for inspiring and guiding young engineers; and for notable service to his professional society."

William Lawrence Saunders Gold Medal to **Louis Buchman,** "For distinguished achievement as a mining engineer; especially in the development of open pit methods for mining copper ores, particularly in the fields of mechanization, electrification and standardization."

Anthony F. Lucas Gold Medal to **Stuart Edward Buckley,** "For outstanding contributions as scientist, technologist, leader, and devoted labors as an author, bringing wide and general understanding of modern petroleum technology to industry and the public."

Erskine Ramsay Gold Medal to **R. Livingston Ireland,** "For his vision, energy, and consistent, courageous belief in and leadership of the American coal industry."

Robert H. Richards Award to **A. W. Fahrenwald,** "In recognition of the increased understanding in theory and practice which has come from his studies and contributions, particularly in flotation, grinding, and classification, and which has contributed in large measure to advancement of the art of mineral beneficiation."

Benjamin F. Fairless Award to **Stephen M. Jenks,** "For his outstanding accomplishment and leadership in increasing production in his company and in the industry."

Daniel C. Jackling Award, Rev. James B. Macelwane

Robert W. Hunt Award to **Otwin Cuscoleca,** for his paper, *Development of Oxygen Steelmaking,* JOURNAL OF METALS, July 1954.

Mathewson Gold Medal to **Jack Washburn, Earl R. Parker, Eugene H. Edwards,** for four papers published in the JOURNAL OF METALS.

J. E. Johnson, Jr., Award to **M. O. Holowaty,** "For his contribution to the literature with respect to the studies made in improving the permeability and productivity of the modern sintering process."

Rossiter W. Raymond Memorial Award to **John J. Gilman,** for his paper published in the JOURNAL OF METALS.

Robert Peele Memorial Award to **Ingvar Janelid,** for his paper, *Drilling Practice in Swedish Mining,* published in MINING ENGINEERING June 1954.

Extractive Metallurgy Div. Award to **T. R. A. Davey,** for papers published in the JOURNAL OF METALS.

Mineral Industry Education Award to **Elmer A. Holbrook,** "For his notable leadership in teaching and administration in the field of mineral industry education; for his administrative services in the field of mineral technology, especially as they appertained to research and safety; and for his encouragement, friendship, and inspiration to his many students and colleagues."

Around the Sections

• E. L. Spieles, Vice Chairman, opened the meeting of the **Wyoming Section** on October 26. Program Chairman Curtis McCarthy introduced Joe Alford, Executive Secretary, Petroleum Branch, who spoke on the AIME. Mr. Alford traced the growth of the Petroleum Branch from a small percentage of the Institute to the substantial percentage it is today. May 17 and 18, 1956 have been selected for the Joint Meeting of the Rocky Mountain Petroleum Sections in Casper. With a budget of several thousand dollars, this will be the largest thing yet attempted by AIME in Wyoming. The meeting will be held in the Gladstone Hotel.

• The **Montana Section** met November 16 at the physics auditorium at Montana School of Mines, Butte. Fred Hames of the metallurgy faculty presented the latest data on "Applications of X-Ray Diffraction in the Mineral Industry." Clifford F. Milkwick was chairman.

• The **Washington, D. C., Section** met at the Cosmos Club on November 8 for cocktails and dinner. Speaker for the evening was H. G. Thomasson of the USGS. His subject was "Some Ground Water Problems in Southwestern United States."

• The **Florida Section** met November 11 at Humphreys Gold Corp., Highland plant, Lawtey, Fla. After lunch there was a short business session, a technical program on titanium oxide, and a guided tour of the plant.

• **The Pennsylvania Anthracite Section** met October 28 at Genetti's Restaurant in Hazleton. W. Julian Parton presided and the speaker was Dan Connelly, Deputy Secretary, Pennsylvania Dept. of Mines, Wilkes-Barre. He gave an illustrated talk on "The Anthracite Flood Prevention Program."

• Members of the **San Francisco Section** were entertained by the **Stanford University Student Section** on November 9. After cocktails and a baked ham dinner, the meeting adjourned to the Geology Corner for the technical session. A. K. Schellinger, formerly director of research for Cerro de Pasco and now associate professor of metallurgy at Stanford spoke on the "Metallurgical Operations at Cerro de Pasco, Peru." After a brief intermission during which the Cerro de Pasco minerals in the Stanford collection were studied, Frank Miller, professor, and W. H. Somerton, associate professor of petroleum engineering, University of California, presented a joint paper on "Subsidence in the Wilmington-Long Beach Area."

• The **Chicago Section** was host on November 9 to 94 students and professors from schools of mining and metallurgy in nearby universities. The visitors toured three integrated steel plants in the Chicago area and were guests of the AIME at the regular monthly dinner.

Representatives attended from Purdue University, University of Wisconsin, Illinois Institute of Technology, and University of Illinois at Urbana and at Navy Pier in Chicago. Groups visited the South Chicago plant of Republic Steel Corp., the Indiana Harbor plant of Inland Steel Co., and the South Works of the U. S. Steel Corp.

David Moore, director of the University of Chicago Executive Training Program, spoke on "The Unhappy Engineers" at the Section dinner meeting. He presented results of extensive sociological research comparing attitudes of engineers with those of other types of industrial employes.

• Annual meeting of the **Minnesota Section** is scheduled for Monday, Jan. 9, 1956 at 10:00 am at the Shrine Auditorium in Duluth. Headquarters will be at the Hotel Duluth.

• A forum was held by the Utah Congressional Delegation at the November 17 meeting of the **Utah Section** in Salt Lake City. Miles P. Romney, manager, Utah Mining Assn., was moderator. Members of the Congressional Delegation are: Senator Wallace F. Bennett, Senator Arthur V. Watkins, Representative H. Aldous Dixon, and Representative William A. Dawson. Subjects included mining legislation, the silver program, access roads, and the uranium purchase program.

• The 63rd annual meeting of the Illinois Mining Institute was called to order Oct. 28, 1955 by President J. W. MacDonald. The all-day session was held at the Abraham Lincoln Hotel in Springfield, Ill. Papers included "Latest Development in Coal Preparation at Freeman No. 4 Mine," by Emery Milligan and "Developments of Stripping in Eastern United States," by James D. Reilly. Guest speaker for the banquet was Joseph L. Andrews, Mayor of Corning, N. Y.

• **As a public service to schools, social organizations, libraries, etc., the Colorado Fuel & Iron Corp. has made available eight 16-mm sound color movies describing the production of steel and important finished products. All of these movies are available on a free loan basis from the Colorado Fuel & Iron Corp., New York Advertising Dept., 575 Madison Ave., New York 22, N. Y.**

Pennsylvania Anthracite Section Holds Annual Meeting

LEFT: Photograph at the Irem Temple Country Club shows some of the 204 people who turned out for the annual meeting of the Pennsylvania Anthracite Section. Meeting was held this year at Dallas, Pa. RIGHT: (left to right) Mrs. William W. Everett; William W. Everett, Section Chairman; AIME President H. DeWitt Smith; R. Y. Williams, receiving Legion of Honor award; Edward G. Fox, past Section Chairman; and Mrs. Edward G. Fox.

President Smith spoke to the meeting and conferred the Legion of Honor upon R. Y. Williams of Pottsville, Pa. AIME Secretary E. O. Kirkendall then presented President Smith with awards from mining societies of France, Germany, Belgium, and England.

NEW OFFICERS: Incoming section officers are: Chairman, Julian Parton; Vice Chairman, Floyd S. Sanders; Secretary-Treasurer, Thomas R. Weichel. Elected to serve on the Executive Committee for three years were: Garfield Schnee, Charles S. Kuebler, John S. Marshall, J. Donald Clendenin, and Earl Lamb.

Annual Meeting Technical Program

(Continued from page 1154)

Industrial Minerals

The Industrial Minerals Div. opens its program with a session on Industrial Waters which will include such papers as: *The Arkansas-White-Red Basins Interagency Study of Water and Power Resources and Its Importance to the Mineral Industry,* by R. S. Sanford; *Planning of Texas Surface Water Supplies,* by S. W. Freese; *Ground-Water for Industry,* by R. G. Kazmann; *Application of Waste Water Reclamation to the Mining Industry,* by R. C. Merz; *Treatment and Reclamation of Waste Waters,* by R. P. Logan; and *Saline Water Conversion Research* by Sidney Gottley.

Following this, there will be a panel discussion on Cement-Aggregate Reaction.

The Industrial Minerals Div. Executive Committee will meet Tuesday afternoon, February 21.

The papers on Air Separation-Milling of Nonmetallic Ores will be presented in a joint session with MBD. These will include: *Flotation of a Canadian Kyanite Ore,* by R. A. Wyman and a Symposium on Air Classifiers to be introduced by A. L. Hall. *Hurricane Air Classifier,* by W. H. Lykken; *Mikroplex Air Classifier,* by A. R. Lukens; and *Sharples Super Classifier,* by R. E. Payne are to be presented in the symposium.

The Minerals Synthesis session will lead off with: *Synthetic Crystals—A New Tool for Research Process Control and Mineralogical Survey,* by E. C. Stewart. Other papers are: *Synthesis of Some Ferrites,* by H. H. Kedesty and A. Tauber; *Synthetic Mica Goes Into Commercial Production,* by R. A. Humphrey; *Synthetic Hydro-Fluorosilicates,* by Alvin Van Valkenburg, Jr.; and *Production of Synthetic Quartz,* by W. H. Charbonnet.

The Chemical Raw Materials session will include the papers on: *Problems of Mining and Exploration of Salt,* by L. E. Reed and C. H. Jacoby; *Lime, the Giant of the Chemical Industry,* by R. W. McAllister; *Materials for Nuclear Power,* by S. B. Roboff; *Ground Disposal of Radioactive Liquid Waste,* by M. I. Goldman and C. P. Staub; and *The Economics of Rutile,* by E. G. Enck.

Papers designated for the Joint Session with SEG, and the Geology Div. are listed under that division.

A General Technical session will include: *The Resources and Utilization of North Carolina Pyrophyllite,* by J. L. Stuckey; *Processing and Marketing Muscovite Block and Film Mica,* by R. D. Thomson; *New and Old Problems in Refractory Materials,* by K. M. Smith; *The Plant for Feldspar-Quartz Glass Sand Production From the Kansas River,* by F. W. Bowdish; *Lightweight Aggregates, Present and Future,* by A. R. Rowen; and *Opportunities for Research on Utilization and Disposal of Water-borne Mineral Wastes,* by A. A. Berk and B. P. Martinez.

Mineral Economics

The first session of the Mineral Economics Div. will contain the following papers: *The General Business Outlook,* by Charles Broderick; *Measurement of Technical Trends in the Mineral Industries,* by Paul F. Yopes; and *Measurement of Trends in the Mineral Industry,* by John J. Schanz, Jr.

The topic of the second session is the economic outlook for domestic industries in strategic minerals now functioning under Government assistance. Clarence A. Fredell will talk on *The Government Point of View* and F. H. Driggs on *The Atomic Energy Commission Point of View* and *The Industry Point of View.*

The third session will feature: *St. Lawrence Seaway and Mineral Industries,* by Ray Stellar; *U. S. Markets for Canadian Minerals,* with presentations: *From Canadian Point of View,* by V. C. Wansbrough; *From U. S. Point of View,* by Elmer Pehrson; and *Economic Aspects of Cold Weather Operations,* by E. B. Spice.

Papers to be read during the last session are: *Economic Aspects of Atomic Fuels,* by Donald Kallman; *How to Determine Whether or Not a Company Starting Up in a Competitive Field Will Pay Its Way and Be Able to Attract Capital,* by E. S. Merrill; and *Rapid Depreciation Procedures Under Recent Changes in the Tax Law,* by H. B. Fernald.

Pacific Conference To Be Held in Seattle

The 1956 Pacific Northwest Conference is scheduled for the Olympic Hotel, Seattle, May 3, 4, and 5. Earl R. Marble, American Smelting & Refining Co., Tacoma, Wash., is General Chairman and assisting him as Metals Branch Program Chairmen are: Whit Rouillard, American Smelting & Refining Co., extractive metallurgy; Earl C. Roberts, University of Washington, physical metallurgy; and Lloyd Banning, U. S. Bureau of Mines, iron and steel. To date sessions have been scheduled for the morning and afternoon on Thursday and Friday, with a morning session on Saturday. The branch luncheons will be held on Thursday and Friday and the informal banquet will be on Friday evening.

PERSONALS

HAL J. JONES

Hal J. Jones has been appointed chief engineer, Houston Technical Laboratories, petroleum instrumentation subsidiary of Texas Instruments Inc., Houston. Mr. Jones will be responsible for the design and development of all instruments and products. For the past three years Mr. Jones has been director of geophysical research in the TI Research Div., Dallas. Prior to joining TI he was research engineer and party chief, geophysical research group, Stanolind Oil & Gas Corp. Mr. Jones has written several technical articles and papers.

Robert R. Bergis is assistant manager, Industrial Supply Co., Roseburg, Ore. Mr. Bergis was mining engineer, Gordon I. Gould & Co., San Francisco.

D. B. Sikka is now in the geological sciences dept., McGill University, Montreal. Mr. Sikka was geologist, Helen mine, Algoma Ore Properties Ltd., Jamestown, Ont.

Richard L. Schumacher, geologist, The New Jersey Zinc Co., Friedensville, Pa., is now with the Manu-Mine Research & Development Co., Reading, Pa.

Alvin W. Knoerr and **George P. Lutjen** are the authors of *Prospecting for Atomic Minerals.* Mr. Knoerr is chief editor and Mr. Lutjen is managing editor of *Engineering & Mining Journal.* *(See page 1083.)*

James I. Craig, formerly plant chief of the Austinville, Va., mine of The New Jersey Zinc Co., has been made superintendent of the Hanover, N. M., operation. Mr. Craig started with the company in 1935 as a mining engineer in Austinville and became plant chief in 1950. He is a mining engineering graduate of Pennsylvania State University.

Richard M. Foose, who received a Faculty Fellowship from the Ford Foundation, is on leave of absence from Franklin and Marshall College and has elected to spend the academic year, 1955 to 1956, at Stanford University in California.

C. M. COOLEY

Charles M. Cooley, editor of MINING ENGINEERING, has resigned and accepted a position as supervisor, sales promotion dept., Spencer Chemical Co., Kansas City. Mr. Cooley came to the Institute in 1951 as associate editor, and was appointed Secretary of the Mining Branch of the AIME in 1952. Before joining the Institute staff, Mr. Cooley was with Climax Molybdenum Co. in Climax, Colo. He is a graduate of Texas Western College of the University of Texas.

H. R. MIDDLETON

Harold R. Middleton has been appointed sales manager, Laubenstein Mfg. Co., Ashland, Pa. Mr. Middleton was with Wilmot Engineering, Co., Hazleton, Pa., as manager of sales promotion and advertising. For many years he has been closely identified with the development and sale of coal preparation equipment in both the anthracite and bituminous coal industry.

Robert Bodu is assistant to the general mill superintendent, Commissariat Français à l'Energie Atomique, Centre de Chatillon, Fontenay aux Roses, Seine, France. Mr. Bodu was formerly with Société des Mines de Zellidja, French Morocco.

ROGER BART

F. N. OBERG

Roger Bart has been appointed manager of International Minerals & Chemical Corp., Research Experiment Station, Mulberry, Fla. Mr. Bart joined the staff of the experiment station as chemical engineering group leader in December 1951. For the past two years he has been supervisor of chemical process development. Before joining International Mr. Bart was an instructor at MIT and a chemical engineer with the research and development divisions of the Standard Oil Development Co. and Du Pont. **F. N. Oberg** has been appointed supervisor of coordinating services at the Florida Experiment Station. Mr. Oberg came to International more than three years ago from American Cyanamid Co. and MIT, where he worked on uranium recovery processes. He also had experience in chemical metallurgy with American Smelting & Refining Co. and Tin Processing Corp. Mr. Oberg has a B.S. in metallurgical engineering from South Dakota School of Mines.

M. A. Buettner is dust control engineer, American Air Filter Co. Inc., Louisville, Ky. Mr. Buettner was formerly engineering duty officer, U. S. Navy, at New York Shipbuilding Corp., Camden, N. J.

K. H. McMahon has returned to Australia. During the past three years Mr. McMahon has worked in seven mines in British Columbia, Washington, Idaho, and Arizona and visited about 50 operations in the U. S. and Canada. Mr. McMahon's most recent position was that of mining engineer, American Smelting & Refining Co., Silver Bell, Ariz.

Harold W. Sorstokke has joined Miami Copper Co., Miami, Ariz., as junior metallurgist.

H. W. Thoms is establishing a consulting office at Edificio Monte Avile No. 1, Calle Segunda, Bello Monte, Caracas, Venezuela. The mailing address is Apartado No. 4510, Correo del Este, Caracas. Mr. Thoms was formerly office geologist, Creole Petroleum Corp., Caracas. Mr. Thoms has been associated with several companies during his long career, including Standard Oil Co. of Bolivia; New Zealand Petroleum Co. Ltd., Gisborne, New Zealand; and United Geophysical Co. Inc., Punta Arenas, Chile. He received a B.S. in mining engineering from Oregon State College in 1918.

Dan William Martin is general manager, Mykobar, Ano Meya, Mykonos, Greece. Mr. Martin was with Magnet Cove Barium Corp., Malvern, Ark.

E. J. Pryor is the author of *An Introduction to Mineral Dressing.* Mr. Pryor is reader in mineral dressing, University of London, England. *(See page 1082.)*

Robert G. Blair, geologist, U. S. Atomic Energy Commission, has been transferred from Grand Junction, Colo., to Austin, Texas.

Robert L. Sandvig is research engineer, Thor Power Tool Co., Los Angeles. Mr. Sandvig was formerly with The Anaconda Co., Butte, Mont.

Peter W. Leidick is assistant manager, Pima Mining Co., Tucson, Ariz. Mr. Leidick was assistant manager, Kaiser Steel Co., Eagle Mountain mine, Calif.

Ralph C. Perkins, Jr., who was drafted in January, is now stationed in Detroit with a Nike Guided Missile Battalion. He was formerly mining engineer for St. Joseph Lead Co. in Missouri and plans to return to the company when he is discharged in January 1957.

C. F. CLAUSEN

Carl F. Clausen, manager of manufacturing research, Portland Cement Assn., Chicago, has been appointed director of the newly created manufacturing process dept. Before joining the Portland Cement Assn. in 1947, Mr. Clausen was assistant to the president for engineering and manufacturing, Pacific Portland Cement Co., San Francisco. Prior to this he was connected with F. L. Smidth & Co., New York, for 13 years. During World War II he served as chief, Non-Metallic Building Materials Section, War Production Board.

Robert W. Clark has purchased the assets of Rayco Electronic Mfg. Co., North Hollywood, Calif. Mr. Clark was formerly engaged in development work for the Lane Wells Co., Los Angeles. He was with the National Broadcasting Co. for many years in the development of television. Mr. Clark is a graduate of Stanford University, Calif. **William V. Mosher** will continue with Rayco as chief engineer.

Samuel C. Fall is resident geologist, Groundhog Unit, American Smelting & Refining Co., Vanadium, N. M. Mr. Fall was formerly engineer for Asarco at Tucson, Ariz. Prior to that he was with The Anaconda Co., Butte, Mont.

Lawrence Adler is now assistant professor of mining engineering at the School of Mines and Metallurgy, Rolla, Mo. Mr. Adler was formerly assistant civil engineer, Dept. of Water & Power, Los Angeles.

J. Richard Lucas is now instructor at Ohio State University, Columbus. Mr. Lucas was formerly field engineer, Joy Mfg. Co., Franklin, Pa.

Henry F. Adams has retired after 36 years of service with the Inspiration Consolidated Copper Co., Inspiration, Ariz. Mr. Adams joined Inspiration in 1916 and during World War I served as a lieutenant in the Engineers. He plans to reside in Pasadena, Calif.

William P. Getty is now assistant vice president—production, Jones & Laughlin Steel Corp., Pittsburgh.

C. T. Baroch has been transferred from the U. S. Bureau of Mines, Electrometallurgical Experiment Station, Boulder City, Nev., to the Intermountain Experiment Station, Salt Lake City. Mr. Baroch's new position will be that of supervising metallurgist.

Homer S. Anderson is manager, Arizona Continental Uranium Inc., Phoenix, Ariz. Mr. Anderson was assistant manager, New York & Honduras Rosario Mining Co., Phoenix.

John H. Dismant has established a consulting office known as Metallurgy & Mining Services at 360 Rood Ave., Grand Junction, Colo. Services include extractive metallurgy, production mining, oil shale, and friction. Mr. Dismant was formerly assistant research metallurgist, Washington State College, Pullman. He recently received his Ph.D. in metallurgy from the University of Utah. He is a 1939 graduate of Colorado School of Mines. Mr. Dismant was assistant professor of metallurgy at New Mexico Institute of Mining and Technology and the first "experimental and mining engineer" of the U. S. Bureau of Mines at the Rifle Oil Shale mine, where he was instrumental in the development of mining techniques, such as hardened bits and the drilling jumbo.

H. L. Talbot, consulting metallurgical engineer, Boston, will be in Turkey until about the middle of February 1956. He is acting as metallurgical consultant to the Turkish Government.

Allan E. Jones has been named deputy manager AEC, Grand Junction Operations Office, Grand Junction, Colo. For the past three years Mr. Jones has been associated with AEC's raw materials procurement program in the Union of South Africa. He has a background of nearly 23 years in various phases of the mining industry.

K. E. CAINE

K. E. Caine has been appointed district manager, Pittsburgh, for the Goodman Mfg. Co., Chicago. Mr. Caine has been associated with Goodman since 1934 in sales work and recently as assistant mining engineer. His headquarters have been in Pittsburgh, but his work has taken him to mining areas all over the country and also to Europe. Mr. Caine was graduated from Carnegie Institute of Technology.

Elmer R. Drevdahl is assistant professor of mining engineering, University of Arizona, Tucson. Mr. Drevdahl was formerly assistant professor at South Dakota School of Mines and Technology, Rapid City.

Weldon P. Zundel has joined The Anaconda Co., Grants, N. M. Mr. Zundel was formerly geologist, American Potash & Chemical Corp., Trona, Calif.

C. C. Conway is now with Clarkson Mfg. Co., Nashville, Ill. Mr. Conway was with Bertrand Goldberg Associates, Nashville, Tenn.

Sylvio de Queirós Mattoso, mining and metallurgical engineer, Cia. Paulista de Mineração, São Paulo, Brazil, is in the U. S. for a one-year training period.

William L. McMorris, III, is with the mineral preparation dept., mineral industries, Pennsylvania State University, University Park. Mr. McMorris was at Missouri School of Mines, Rolla.

Francis T. Coleman is design engineer, Kennecott Copper Corp., Ray, Ariz. Mr. Coleman was formerly office engineer, Herkenhoff & Turney, Santa Fe, N. M.

Robert C. Hills has been elected executive vice president and a director of Freeport Sulphur Co., New York. Mr. Hills joined Freeport in 1934 as an assistant chemist in the company's Grand Ecaille laboratory in Louisiana. He was named assistant to the president in 1947 and elected a vice president in 1950. Mr. Hills is a graduate of Tulane and Cornell.

OBITUARIES

Arthur L. Hamilton (Legion of Honor Member 1903), a retired mining engineer of Lisbon, N. H., died Mar. 20, 1955. He was born in Fond du Lac, Wis., in 1876. After receiving his B.S. from Massachusetts Institute of Technology in 1900, Mr. Hamilton was employed by Boston & Montana Smelter, Great Falls, Mont. He was later secretary and treasurer, Marinette Iron Works Mfg. Co., Marinette, Wis. After a long period in mining activities in Alaska, Mr. Hamilton became president of International Tag Co., Chicago. He was with this firm for many years.

Lafayette Hanchett
An Appreciation by
George M. Gadsby

Lafayette Hanchett (Member 1900), retired chariman of the board, Utah Power & Light Co., and for more than a half century a leader in mining, business, and banking, died Sept. 11, 1955 in a Salt Lake City hospital. He was 87.

Though retired from his long and active career in business for some years, Lafayette Hanchett was a familiar figure to many in Salt Lake City. *The Salt Lake Tribune* wrote of the man, who until shortly before his death, "strode firmly and with near ramrod erectness down the city's streets. These regular visits downtown typified his continuing mental and physical vigor and the keen awareness of all that went on about him in the city, state, nation, and the world."

Mr. Hanchett, a recipient of many honors—among which was the Legion of Honor of the AIME—was often described as "a man of vision," "a man of courage," "a man of judgment," "of humor, letters, and a world traveler."

People sought him for advice on mining, banking, electric power, business in general, or even on Stanley Steamers.

However, among his wide circle of friends, he was referred to as "The Old Sheriff," for it was in the book of that title which he authored in 1937 that he revealed himself as a most philosophic authority on most of those subjects.

While not "from" the West—he was born nearly 88 years ago in the state of New York—he was in the truest sense of the word "of" the West.

Mr. Hanchett not only saw the West grow up, he helped it grow up. After spending his boyhood in some of Colorado's tough, rough, brawling camps, he was graduated from Denver University and then spent much of his time between 1890 and 1904 in Colorado's Idaho Springs mining district.

An injury to his father projected him into the spot of assistant manager of the Lamartine mines along about 1890. Then, as one of the first of a long series of associations with Samuel Newhouse, an early Colorado freighter who later became a prominent mining man and Utah businessman, he managed the Argo Tunnel Co. in the Idaho Springs area.

Leaving Colorado at about the turn of the century, Mr. Hanchett arrived in Utah in style. He proudly drove a Stanley Steamer, which took its place as one of 31 automobiles in the state, into the valley of the Great Salt Lake.

As an associate of Mr. Newhouse, he was connected with such fabulous mines as the Highland Boy, in the Bingham mining district. He later managed the Boston Consolidated, when the now famous Louis S. Cates was superintendent, until the mine was taken over by what was then Utah Copper Co.

It was at Utah Copper that the first power shovel was introduced into open cut mining operations. This steam-powered shovel was capable of loading 100 tph of material. Today Kennecott's electric shovels handle more than 800 tph.

When Boston Con was merged with Utah Copper in 1910, Mr. Hanchett and his wife traveled extensively abroad. Upon their return to the Intermountain West, Mr. Hanchett went to Wendell, Idaho, and managed the Thousand Springs Power Co. until 1916.

World War I projected him into the job of assistant director of the U. S. Explosives plant at Nitro, W. Va. D. C. Jackling, with whom he had been closely associated in Utah, was director of U. S. Explosives. Mr. Hanchett served in this job as a presidential appointee as a dollar-a-year man to further the war effort.

Returning to Utah at the close of the war, he joined Utah Power & Light Co. in 1919 as a director, served as president from 1920 until 1929 and then as chairman of the board, a position he held until 1953.

Aided by his unexcelled judgment, foresight, and keen business acumen, Utah Power & Light Co. paced the growth of the Intermountain Empire.

At a farewell gathering marking his retirement from Utah Power & Light Co., Mr. Hanchett was described as Utah Power's "Elder Statesman . . . a venerable bridge, he spanned the gap from the Old West to the New. From the 'palmy days' of yesteryear when thousands of men swarmed over the nearby mountains searching for gold, to the modern days of today."

Hugo E. Hanser (Member 1918) of Brooklyn died July 14, 1955. Mr. Hanser was an attorney and a mining and industrial engineer. He was born in Brooklyn in 1889. Mr. Hanser received a B.S. in 1911 and a C.E. degree in 1936 from the University of Nevada. His other degrees include an LL. B. in 1913 from Lincoln-Jefferson University, Hammond, Ind., and an M.Ad.E. from New York University in 1944. Mr. Hanser's early experience was gained in mines and mills in Nevada. From 1912 to 1919 he was employed as assistant engineer by Nevada Consolidated Copper Co. He was later project manager and development engineer for Barrett Co. of Allied Chemical & Dye Corp. From 1925 to 1926 Mr. Hanser was a construction engineer for Nard Corp., New York, and from 1926 to 1928 he served as deputy superintendent of industries for the Dept. of Correction, New York State. Mr. Hanser was also with H. J. Seibert & Associates, New York; Gertler & Co., New York; and the Board of Transportation of the City of New York. In 1948 he was with the U. S. Army Military Government in Korea as industrial consultant. Mr. Hanser was the author of numerous articles on industrial engineering, efficiency, and reogranization and also on economics, finance, and resources. He was licensed as a lawyer to the U. S. Supreme Court in 1933 and to the Interstate Commerce Commission in 1938.

James A. Hogle (Member 1925), founder and senior partner of J. A. Hogle & Co., Salt Lake City, died Sept. 14, 1955. He was a civic leader, philanthropist, and nationally known financier. Mr. Hogle was born in Salt Lake City in 1876 and was graduated from Yale Sheffield Scientific School with a Ph.B. in 1899. Mr. Hogle later studied at Columbia University School of Mines in New York, completing his course there in geology and mining in 1902. While taking graduate work he was employed by Anaconda Copper Mining Co., Anaconda, Mont., doing assaying and sampling, and later as an engineer in the company's office in Butte, Mont. Mr. Hogle was a consulting engineer from 1902 until 1912 when he entered brokerage activities in Salt Lake City and Ogden. He founded Hogle & Co. in 1915. Mr. Hogle held seats on the New York Stock Exchange, the New York Curb Exchange, and the Los Angeles Stock Exchange. He was a former member of the board of governors of the New York Curb Exchange, the Investment Bankers Assn. of America,

Necrology

Date Elected	Name	Date of Death
1924	A. B. Bagsar	Oct. 7, 1955
1939	William H. Burgin	Oct. 6, 1955
1900	Charles A. Chase	Aug. 31, 1955
1936	Otis L. Jones	May 1955
1952	Lincoln Kilbourne	Oct. 5, 1955
1936	John W. MacKenzie	Unknown
1916	Dale L. Pitt	Sept. 10, 1955
1952	Herbert W. Rich	Oct. 5, 1955
1955	Lynn D. Speer	Sept. 15, 1955
1906	Norman C. Stines	Unknown

and the Chicago Board of Trade. In 1926 Mr. and Mrs. Hogle presented the Hogle Zoological Gardens to Salt Lake City. Later gifts expanded it to one of the largest zoos in the West.

Estey A. Julian (Member 1915) of San Francisco died Aug. 2, 1955 in Addis Ababa, Ethiopia. Mr. Julian, president of American Chrome Co. and vice president and general manager of Goldfield Consolidated Mines Co., had been in Addis Ababa for about six weeks on a business trip when he was stricken. He was born in Licking, Mo., in 1883 and was graduated from William Jewell College, Liberty, Mo., in 1904. Mr. Julian gained his early experience in Florence, Colo., with Dorcas Milling Co. and with U. S. Reduction & Refining Co. Later he went to Nevada and in 1907 became superintendent for Tonopah Mining Co. In 1919 Mr. Julian was named vice president and general manager of Goldfield Consolidated Mines Co. and in 1938 he took charge of the Livengood Placers Project in the Yukon River area in Alaska. He became president of Sutter Butte Canal Co. in 1942. Mr. Julian was a member of the Pacific Union and Bohemian clubs.

Frank L. Kennicott (Member 1937) died June 29, 1955. Mr. Kennicott was superintendent, Tonapah Development, Summit King Mines Ltd., Fallon, Nev. He was born in Delta, Colo., in 1897. After working in metal mining in various capacities, Mr. Kennicott joined Wellington Mines Co., Breckenridge, Colo., in 1924 and became mine foreman in 1927. He was later mine foreman, London Gold Mines Co., Alma, Colo,; in charge of operations, Terrible Dunderberg mine. Silver Plume, Colo.; general superintendent, Moline Mining & Milling Co., Cerrillos, N. M.; and mine foreman, Carissa mine, South Pass City, Wyo.

Lewis P. Larsen (Member 1920) died July 14, 1955 in Spokane. He was president and founder of Pend Oreille Mines & Metals Co., Metaline Falls, Wash., and president of Reeves MacDonald Mines Ltd., Vancouver, B. C. Mr. Larsen was born in Fredericia, Denmark, in 1876 and studied at the Royal Naval Academy in Denmark from 1890 to 1892. From 1894 to 1899 he worked as a miner in Silver City and the Coeur d'Alenes and from 1899 to 1902 Mr. Larsen was in charge of developing prospects in Idaho and Montana. He later did exploration work for Larsen & Greenough at Troy, Mont., and then spent two years with the Last Chance mine, Northport, Wash. Mr. Larsen discovered the cement rock deposit that started the town of Metaline Falls.

Donal F. McCarthy (Member 1934) died suddenly of a heart attack on May 10, 1955. A patent attorney with the New York firm of Pennie, Edmonds, Morton, Barrows & Taylor, Mr. McCarthy dealt chiefly with patents relating to chemistry and metallurgy. He was born in Denver in 1896 and received his B.S. in chemical engineering from the University of Washington. Later he studied at Georgetown University, Washington College of Law, and New York University. From 1910 to 1917 Mr. McCarthy was employed by Anaconda Reduction Works in Montana. Following service in World War I with the U. S. Army Ordinance Corps, he was with the Washington State Highway Commission. Before becoming a patent attorney in 1927, Mr. McCarthy was a patent examiner with the U. S. Patent Office, examining mechanical patent applications.

Frederick Danvers Power (Legion of Honor Member 1891) died in Burwood, New South Wales, Australia, on June 29, 1955. He was a retired mining engineer, consultant, and the author of *Pocket Book for Miners and Metallurgists*. Mr. Power was born in England in 1861 and was trained at the Royal School of Mines in London and the Clausthal Mining Academy in Germany. He went to Australia in 1885 and after working as an assayer became a consultant. Apart from Australia, his work took him to Tasmania, New Zealand, New Caledonia and the South Sea Islands. In 1902 he was made a lecturer in mining at the University of Sydney and in 1904 a government examiner for mine manager certificates. Mr. Power, twice president of the Australasian Institute of Mining and Metallurgy, was also a member of the Institution of Mining and Metallurgy and the Geological Society of London.

Henry P. Smith (Member 1911) retired mining engineer, died Sept. 4, 1955. Mr. Smith was born in Springfield, Mass., in 1872 and was graduated from Sibley College, Cornell University, in 1899. He was first employed by R. H. Smith Mfg. Co. in Springfield and then went to Colorado, where he was employed in various capacities with a mining company in Silverton. He was later a mechanical engineer for Smuggler Union Mines Co., Telluride, Colo. In 1903 Mr. Smith joined Guanajuato Reduction & Mines Co., Guanajuato, Mexico, as construction engineer. He was later chief of construction, assistant manager, and in 1909 general manager. Mr. Smith retired in

MEMBERSHIP

Proposed for Membership
Mining Branch, AIME

Total AIME membership on Oct. 31, 1955 was 23,386; in addition 2007 Student Associates were enrolled.

ADMISSIONS COMMITTEE

P. D. Wilson, Chairman; F. A. Ayer, Vice-Chairman; A. C. Brinker, R. H. Dickson, T. D. Jones, F. T. Hanson, Sidney Rolle, O. B. J. Fraser, F. T. Sisco, Frank T. Weems, R. L. Ziegfield, R. B. Caples, F. W. McQuiston, Jr., A. R. Lytle, H. R. Wheeler, L. P. Warriner, J. H. Scaff.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Jasper—Boggs, Delbert L., Jr. (C/S—S-J)
Heflin—Loudermilk, Eldridge L. (J)
Arizona
Silver Bell—Miller, Robert L. (R. C/S—S-J)
California
Burlingame—Davis, Thomas Dewey (A)
Angels Camp—Allsman, Lewis S. (M)
Oakland—Stampley, Richmond M. (A)
Pasadena—Howell, B. N. (R. M)
San Francisco—Schwyn, Richard B. (M)
Colorado
Climax—Wallace, Stewart R. (R. C/S—S-M)
Denver—Lintner, Robert E. (R. C/S)
Grand Junction—Boyle, Thomas L. (R. M)
Grand Junction—Lynch, Harold Carpenter (A)
Grand Junction—McArthur, Charles K. (C/S—J-M)
Grand Junction—Rigg, John B. (J)
Connecticut
New Canaan—Winship, Charles H. (A)
Florida
Plant City—Nagel, William A. (M)
Michigan
Ishpeming—Erck, Louis John (M)
Mt. Clemens—Oliver, Lloyd R. (M)
Negaunee—Karkkainen, Carlo Werner (A)
Montana
Anaconda—Stokke, Melvin A. (M)
Nevada
Henderson—Godbe, Murray C., III (R. J)
Winnemucca—Price, Marion E. (M)
New Jersey
Princeton—Bonini, William E. (M)
New Mexico
Carlsbad—Carey, Thomas Lawrence (R. C/S—A-M)
Carlsbad—Conder, Lory S. (R. C/S—S-M)
Grants—Hoine, Charles F. (M)
New York
Flushing—Miller, Hugh M. (R. C/S—S-J)
Niagara Falls—Papacharalambous, H. G. (J)
Staten Island—Holtz, Theodore H. (M)
Ohio
Nelsonville—Ong, Philip H. (M)
Pennsylvania
Greensburg—Gelston, James S. (M)
Pittsburgh—Ferguson, John R., Jr. (M)
Pittsburgh—Smith, Frank W. (M)
South Dakota
Belle Fourche—Beeman, Fred A. (C/S—S-A)
Tennessee
Mascot—Polhemus, James H. (C/S—A-M)
Texas
El Paso—Milliken, Clinton Lloyd (A)
El Paso—Siegel, Leon (M)
Utah
Bingham Canyon—Stevenson, Frank B. (R. C/S—S-J)
Bountiful—Gardner, Sherman Donald (M)
Bountiful—Olin, John R. (A)
Castle Dale—Metcalf, Henry S. K. (M)
Hiawatha—Jackson, Thomas C. (M)
Riverton—Flanders, Oden Eugene (A)
Salt Lake City—Bentley, Curtis Keith (A)
Salt Lake City—Briggs, Orval Loni (A)
Salt Lake City—Guay, Wilbur Joseph (R. C/S—J-A)
Salt Lake City—Hendel, Charles William, III (M)
Salt Lake City—Kasper, Mark Theodore (M)
Salt Lake City—Knudsen, John Fredrick (R. M)
Salt Lake City—Parker, Robert LeWarne (A)
Salt Lake City—Phillips, William Revell (J)
Salt Lake City—Smith, Cecil H. (J)
Sandy—Hewitt, Loyd A. (M)
South Salt Lake City—Hall, William B. (M)
Washington
Northport—Barkley, James R. (C/S—J-M)
Seattle—Stoll, William Max (R. C/S—J-M)
Alaska
College—Wolfe, Ernest N. (M)
Canada
Nova Scotia, Halifax—Riley, Rolland L. (A)
Ontario, Manotick—Buck, Walter K. (C/S—J-M)
Ontario, Ottawa—Donaldson, John W. (J)
Quebec, Opemisca—Cooke, Frederick G. (M)
Quebec, Opemisca—Folinsbee, John C. (J)
Quebec, Thetford Mines—Penhale, Alfred L. (M)
Mexico, D. F.
Tacubaya—Madero, Enrique (M)
Peru
Lima—Dym, Koert A. (A)
Lima—Rodriguez, Daniel M. (R. C/S—S-M)
South West Africa
Tsumeb—Reid, Thomas Lestock (M)

1929 and had since then made his home in Laguna Beach, Calif. It is of interest to note that Bernard MacDonald, Joseph MacDonald, and Louis S. Noble signed Mr. Smith's AIME application. Mr. Smith was married to Josephine MacDonald, daughter of Bernard MacDonald, in 1907.

William Willard Taylor (Legion of Honor Member 1897) died May 25, 1955 at his home on Signal Mountain, Tenn. He was an executive and mining engineer. Mr. Taylor was born in Lapeer, Mich., in 1871. He received a B.S. in mining engineering in 1893 and a Ch.E. degree in 1914 from the University of Michigan. Mr. Taylor started as a chemist in 1893 with Mansfield Iron mine and later worked with Illinois Steel Co. and St. Louis Blast Furnace Co. In 1896 he joined Iron Gate Furnace Co., Iron Gate, Va., and became superintendent in 1897. Mr. Taylor was also at various times general manager, Allegheny Ore & Iron Co.; vice president, Victoria Coal & Coke Co.; and president, Oriskany Ore & Iron Co. In 1912 he moved to Lynchburg, Va., and with an associate built the Oriskany blast furnace at Reusens, Va. This is one of the few furnaces of that era still being operated. Mr. Taylor built the Benedict Coal Corp. plant at St. Charles, Va., and was vice president and general manager, Chattanooga I. & C. Co. and Central I. & C. Co. He retired in 1920 and moved with his family to Signal Mountain. His winters were spent in Florida where he had large citrus grove interests. Mr. Taylor was the author of several technical papers on blast furnace practice.

Hewitt S. West (Member 1951) died Sept. 2, 1955 in Memorial Hospital in New York. He was president of Haile Mines Inc., Tungsten Mining Corp., and Manganese Inc. Mr. West was born in Glens Falls, N. Y., in 1890 and was graduated from Yale Sheffield Scientific School in 1912. For the next two years he was an engineer with the Underwriters Assn. of the Middle Dept., Philadelphia. He was then engineer and special agent for Glens Falls Insurance Co., and from 1916 to 1917 vice president of Cuban Oil Co., Havana, Cuba. After serving with the 22nd Engineers in the U. S. and France during World War I, Mr. West was with Acer Paper Co., Montreal, from 1919 to 1921 and with Abitibi Paper Co., New York, 1921 to 1925. He was president of F. R. Cruikshank & Co., New York, from 1925 to 1935. Mr. West became president of Haile Mines Inc. in 1935, president of Tungsten Mining Corp. in 1945, and president of Manganese Inc. in 1949. He was also chairman of the board of Coconino Pulp & Paper Co., Flagstaff, Ariz. Mr. West took an active part in the American Mining Congress.

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Coming Events

Dec. 15, AIME, Ohio Valley Section, Battelle Memorial Institute, Columbus, Ohio. B. H. Alexander, speaker.

Dec. 26-31, American Assn. for the Advancement of Science, Atlanta.

Jan. 4-6, 1956, Fourth Annual Spectroscopy Seminar, University of Florida. For information write: Prof. W. T. Tiffin, College of Engineering, Gainesvile, Fla.

Jan. 5, AIME, Utah Uranium Subsection, 7:30 pm, Arches Cafe, Moab, Utah.

Jan. 9, Minnesota Section, annual meeting, 10:00 am, Shrine Auditorium, Duluth. Headquarters, Hotel Duluth.

Jan. 25-27, Engineers Joint Council General Assembly, Statler Hotel, New York.

Feb. 2-3, Governor's Industrial Safety Conference, 6th annual statewide meeting, Fairmont Hotel. San Francisco. Mineral Extraction Section meets Feb. 2 and 3 at 1:00 pm.

Feb. 20-23, AIME, Annual Meeting, Statler and New Yorker hotels, New York.

Feb. 27-29, Rocky Mountain Section, American Assn. of Petroleum Geologists, 6th annual convention, Municipal Auditorium Annex, Denver.

April 6, Pennsylvania Anthracite Section, Necho Allen Hotel, Pottsville, Pa. John Cipyak will speak on "Machine Accounting as Applied to Mining Industry."

Apr. 9-11, AIME, Open Hearth and Blast Furnace Conferences, Netherland Plaza Hotel, Cincinnati.

Apr. 9-11, Canadian Institute of Mining and Metallurgy, annual meeting, Chateau Frontenac, Quebec City.

Apr. 23-26, American Assn. of Petroleum Geologists, Conrad Hilton Hotel, Chicago.

May 3-5, AIME, Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

May 7-9, American Mining Congress, Coal Convention, Netherland Plaza Hotel, Cincinnati.

May 17-18, Rocky Mountain Petroleum Sections, joint meeting, Gladstone Hotel, Casper, Wyo.

June 16-23, Fifth World Power Conference, Vienna.

June 17-22, American Society for Testing Materials, annual meeting, Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

Aug. 23-25, National Council of State Boards of Engineering Examiners, Hotel Statler, Los Angeles.

Sept. 4-11, International Geological Congress, Mexico City.

Sep. 29-Oct. 1, Society of Exploration Geophysicists, 26th annual meeting, New Orleans.

Oct. 1-4, American Mining Congress, Mining Show, Shrine Auditorium, Los Angeles.

Oct. 8-10, AIME, Institute of Metals Div., Allerton Hotel, Cleveland.

Oct. 14-17, AIME, Petroleum Branch, Biltmore Hotel, Los Angeles.

Feb. 24-28, 1957, AIME Annual Meeting. Roosevelt and Jung hotels, New Orleans.

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